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SATELLITES FOR WORLD COMMUNICATION

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MAIN READING ROOM

HEARINGS

BEFORE THE

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EIGHTY-SIXTH CONGRESS

FIRST SESSION

MARCH 3 AND 4, 1959

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SATELLITES FOR WORLD COMMUNICATION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Tuesday, March 3, 1959.

The committee met at 10 a.m., in room 359, House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The committee will please come to order.

Mr. Ducander, tell us when the committee can look forward to having its own committee room.

Mr. DUCANDER. I think they can look forward to having the room next Friday, but there won't be any chairs for the members to sit on because we have ordered those through the Clerk of the House and I checked on them just about 2 days ago and they haven't arrived as yet. They are on order.

The carpeting and the drapes are on order. I took the liberty of selecting the decor for the chairs and the drapes and the carpeting so I think it will be a nice-looking room, as good as we can get with that low ceiling.

The CHAIRMAN. Will you keep behind them on it because the sooner we do have our own committee room, the more satisfied the members of the committee will be.

In that connection, when we adjourn today, we will meet tomorrow morning, but due to the fact that we do not have our committee room—we are not able to get a committee room, I am told—we are unable to meet until 10:30 tomorrow morning. The rooms that we have been trying to get for meeting purposes will be taken until then and therefore the committee, when it adjourns today, will meet tomorrow morning at 10:30.

I have been handed this memorandum that I think every member of the committee would be interested in. It is a report that was phoned us from NASA just a few moments ago. It reports that at 9 a.m. this morning the satellite which was fired last night was 72,400 miles from the earth. It was traveling at a rate of 6,518 miles per hour. It is estimated that at 11 a.m. it will be 84,800 miles from the earth and will be traveling at the rate of 6,162 miles per hour. It is anticipated that we will be able to track the satellite until it is 400,000 miles away. It is estimated that it will pass the moon at 2 p.m. tomorrow and will pass at a distance of 35,000 miles.

Thereafter it will go into orbit around the sun.

That is the end of the report that was handed me from NASA. Any questions?

No questions, so we will proceed.

This morning we are privileged to have before the committee Mr. Roy W. Johnson, Director, Advanced Research Projects Agency; Paul A. Price, also of ARPA; Dr. Hans K. Ziegler, Director of Astro-electronics, U.S. Army Signal R. & D. Laboratory, Fort Monmouth, N.J.; Mr. Lawrence P. Gise, and Mr. William H. Godel, both of ARPA. They are all here to testify on the subject of the international telecommunications and communications satellites.

I understand, of course, a good deal of this is classified information. I am going to ask these witnesses if they will go to the limit that they are permitted without divulging any classified information before suspending and after that, of course, we will have to go into executive session.

But, in the interests of giving the press as much as we can and the public as much as we can on this subject, I think it is highly important that we stay in open session just to the very limit that we are permitted to do.

This morning I call first on Mr. Roy W. Johnson, Director, ARPA.

Are there prepared statements? I understand they are being prepared and will be along a little later.

Why not then begin in an informal way? Mr. Johnson, you could start out and give us your ideas on this subject and when the statements arrive, we can refer to them.

STATEMENT OF ROY W. JOHNSON, DIRECTOR, ADVANCED RESEARCH PROJECTS AGENCY [1]

Mr. JOHNSON. Mr. Chairman, I would like to be permitted if agreeable to you, to read a short statement on the Discoverer launched. Several members of the committee have interrogated us as to just what has gone on and with your permission could I read this statement first?

The CHAIRMAN. We would like very much to have it. We may ask you a question or two.

Mr. JOHNSON. Thank you, sir.

At 1649 eastern time February 28, this year, Discoverer I was launched from Vandenberg Air Force Base in California. The launching, despite the fact that Discoverer I Thor-Hustler space-launching vehicle was an entirely new one, was completely successful.

Preliminary estimates, based on launch phase telemetry, placed the Discoverer I perigee at 146 statute miles, the apogee at 558 statute miles, and the period at 96 minutes.

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[1] Mr. Roy W. Johnson was born in 1905 in Michigan City, Ind., and was graduated from the University of Michigan in 1927. Most of Mr. Johnson's career, starting in 1930, was spent with the General Electric Co. in various administrative capacities. He was vice president and executive vice president from 1948 to 1958.

During World War II he was associated with the War Production Board. The latter period of this tour of duty he was Director of the Facilities Bureau.

Effective April 1, 1958, he resigned from the General Electric Co. to become the first Director of the newly created Advanced Research Projects Agency of the Department of Defense in Washington, which, as its name implies, directs specialized advanced research projects including military outer space and defense from ballistic missiles.

Mr. Johnson resides on Wire Mill Road in Stamford, Conn. He was married in 1927 to the former Ellen Lehtinen, of Peterboro, N.H., and they have one daughter, Kristine, age 12.

The satellite's life expectancy will be in excess of 30 days.

Now, despite the successful launching, no capable United States tracking facilities have as yet been able to get a positive fix on the satellite. Tracking installations both in the United States and overseas have been and are conducting a search for the vehicle. There is a distinct possibility that the satellite is in orbit but that the radio transmitters are not functioning properly, perhaps due to battery deficiency.

In this regard, sporadic signals have been received which would tend to confirm that an orbit has been achieved by the Discoverer. Tracking stations have picked up random signals which approximate the predicted position of the satellite on the frequency of the Discoverer radio beacon.

The most reliable of these were acquired at Edwards Air Force Base, Vandenberg Air Force Base, and at Annette, Alaska.

However, the 26 or so radar stations searching for Discoverer, including the satellite detection fence, have reported no definite detection information to Space Track which is coordinating the entire tracking effort.

Now, visual and optical tracking installations in the United States and overseas were not alerted to Discoverer, or to watch for Discoverer because due to the orbit and time of launch, the satellite will be in the sun throughout almost all of its orbital trajectory. The only exceptions will be when the satellite is crossing over the polar areas. Therefore, optical and visual detection, or moon watch detection methods have no capability against a satellite in the sunlight.

Discoverer I was launched primarily as a test of the propulsion, guidance, and control equipment. While we feel we have conducted an adequate test of the propulsion system, due to the failure of the radio transmitters we have not conducted an adequate test of the equipment to stabilize the satellite in orbit or the tracking network.

The second Discoverer launch will have essentially the same test objectives as did Discoverer I. Following successful tests of the satellite stabilization equipment and the tracking network, recovery of a Discoverer satellite will be attempted.

The later Discoverer vehicles planned for recovery will contain biomedical specimens. The experimental results to be obtained from the recovery of these biomedical specimens will prove helpful to the United States man-in-space program.

At the present time we plan to launch about one Discoverer vehicle per month during the rest of the calendar year. The large number of vehicles is predicated upon the fact that the satellites will be placed in low polar orbits with very short orbital lives.

Furthermore, the stabilization and the recovery techniques represent new steps in the progressive development of space vehicles and therefore several attempts and tests will be necessary to establish the reliability of the system.

The capability to stabilize and recover satellites has many important applications in addition to man in space, namely, for developing satellite communications systems, meteorlogical systems, mapping techniques and the like.

Therefore, recognizing the urgency built into the satellite recoverability, the Advanced Research Projects Agency, working with the

Department of the Air Force, is pursuing the Discoverer program with great vigor.

In closing, I should like to invite your attention to the fact that this is a military research and development program for the Department of Defense. Bound up in this program are the very substantial tracking requirements attendant to a space vehicle system which represents another step forward in sophistication. We are seeking, through the tracking capabilities of the Department of Defense, to develop an adequate guidance and control and tracking operation which does not depend on installations not under the control of the Department of Defense.

We feel this is an essential requirement if we are to fulfill our responsibilities for the national security of the Nation, even as it relates to space systems.

That is the end of the statement.

The CHAIRMAN. Mr. Johnson, let me ask you this: I noticed in one of the papers yesterday complaint was made on the eastern seaboard that they were not alerted to the firing of the Discoverer and therefore were not able to participate in the effort to detect the satellite as it passed over the eastern seaboard in its orbit of the two poles. Why was that? Some of the scientists felt that they could have helped detect the Discoverer.

Mr. JOHNSON. Mr. Chairman, this is the reason I included in this statement the reference to the fact that visual tracking was impossible. The gentleman was quoted in the story as saying his setup was not notified. This is true, as I understand, because the visual tracking he was capable of doing was impossible in this situation.

The satellite had been deliberately planned to orbit in such a manner that it would be in the sun at all times for the first 30 days and when a satellite is in the sun, obviously you can't track it visually.

The CHAIRMAN. You track it by radar?

Mr. JOHNSON. That is right.

The CHAIRMAN. Those people did not have radar?

Mr. JOHNSON. They did not have radar facilities.

The CHAIRMAN. They were relying entirely on visual tracking?

Mr. JOHNSON. Yes, sir.

Mr. SISK. Would the chairman yield at that point?

The CHAIRMAN. Surely.

Mr. SISK. In your concluding statement you mentioned the fact that this was strictly a military program and that one of the objectives was to develop military tracking, exclusive of any other type of control or tracking device.

Now, was that a part of the reason why certain of the stations were not notified or were not asked to participate in the program?

Mr. JOHNSON. In this particular case, in this first shot, if visual tracking had been possible we would have asked the Smithsonian to participate in this first attempt. They are a part of the space-track system.

The reason for the last statement I made here is, however—there must be an understanding in our military program that there will be occasions when we will not ask non-Department of Defense people to participate because we do have to develop a military system that would be usable in time of emergency.

Mr. SISK. I am not complaining about that, but in view of your statement, which I think is something I have not heard mentioned before, I was just curious to know to what extent that particular policy was pursued in this case.

In other words, hereafter in many of these cases you will depend strictly upon military?

Mr. JOHNSON. That is right, sir, and we did have one program to attempt to determine whether we could do this sort of a thing in secrecy—you will recall Project Score was an attempt in the military area to do this.

Mr. SISK. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Is it possible that ARPA wanted to check whether other people can find a satellite with an absence of information?

Mr. JOHNSON. In this case we did not alert the world to the frequencies we were using because it was necessary for us to—we did not want to allow amateurs to trigger the satellite and receive the information prior to our getting it, so there will be many occasions on these kinds of satellite launchings where we will not announce the frequencies in advance.

Mr. ANFUSO. For military objectives?

Mr. JOHNSON. For military reasons, that is correct.

The CHAIRMAN. The Discoverer program has many advantages, it seems to me, that are usable for the program of Man-in-Space. Is that correct?

Now, has it possibilities for satellite communications?

Mr. JOHNSON. Yes.

The CHAIRMAN. And then for reconnaissance; is that correct?

Mr. JOHNSON. And meteorology.

The CHAIRMAN. Which would mean weather information.

Mr. JOHNSON. The Discoverer series does not have a specific reconnaissance possibility. Of course, what we learn from Discoverer could lead to a reconnaissance possibility at a later date.

The CHAIRMAN. It is certainly applicable.

Mr. JOHNSON. The techniques being used here could be beneficial to recovery.

The CHAIRMAN. You are orbiting a satellite in areas fairly close to the globe and since you are doing that it seems to me that all of the experience that you have in that orbit would be applicable to later use in reconnaissance.

Mr. JOHNSON. That is right, sir.

Mr. ANFUSO. Mr. Chairman, can we know something about the payload and also the thrust used?

Mr. JOHNSON. Yes. We have some data here. The thrust was 150,000 pounds. The height of the first stage was 66 feet. The second stage was 18.8 feet, and the second stage had 15,000 pounds of thrust, so it was a total of 165,000.

The payload was 40 pounds of telemetry equipment. It is of advanced design with new circuitry techniques and, of course, has some miniaturization experiments. It will operate on 15 channels, 10 continuous and 5 commuted, which can relay continuously about 100 pieces of vital information on the performance of the vehicle.

Mr. ANFUSO. The total weight of the satellite was what?

Mr. JOHNSON. Thirteen hundred pounds. This package I am talking about weighed 40 pounds.

It also contained an infrared horizon scanner which looks out in front of the vehicle to scan for the horizon sensing systems of the guidance system to orient the satellite in an exact horizontal position. We were trying to stabilize this satellite in a constant position and the horizon scanner would do this and to achieve the stabilized platform it is an important part of these experiments. In other words, to prevent this tumbling.

Mr. ANFUSO. This is the first polar satellite?

Mr. JOHNSON. Yes.

Mr. ANFUSO. Do you know why the Russians haven't attempted one?

Mr. JOHNSON. Geography. They don't have the geography to do this. We didn't have, of course, until we went to Vandenberg. We don't have it at Canaveral.

The CHAIRMAN. You consider the project a successful one; do you?

Mr. JOHNSON. So far as the launch is concerned, we think it was very successful. So far as the information we are getting from the satellite is concerned, it is not successful.

The CHAIRMAN. It was first launching of a satellite from Vandenberg; wasn't it?

Mr. JOHNSON. That is right.

The CHAIRMAN. It was the first use of the Bell-Hustler second-stage system?

Mr. JOHNSON. Right.

The CHAIRMAN. It was the first orbit of the poles, the North and South Poles?

Mr. JOHNSON. That is right.

The CHAIRMAN. It is the first effort to stabilize a satellite in orbit.

Mr. JOHNSON. Yes, and we had perfect telemetry for the first 9 minutes, which means that we knew for the 9-minute period that it went into orbit and we have a pretty good fix on the perigee and the apogee.

The CHAIRMAN. How far out was it in 9 minutes?

Mr. JOHNSON. Way past Hawaii.

The CHAIRMAN. In other words, leaving the Pacific coast, it passed Hawaii in less than 9 minutes.

Mr. JOHNSON. That is right, and we had a record of that.

The CHAIRMAN. That is how many nautical miles?

Mr. JOHNSON. 2,500.

The CHAIRMAN. 2,500 nautical miles?

Mr. JOHNSON. Yes.

The CHAIRMAN. About 3,000 statute miles?

Mr. JOHNSON. That would be about right.

The CHAIRMAN. Any further questions?

I think your report is excellent. We appreciate it, too.

Mr. ANFUSO. How could it pass Hawaii? It was going in a different direction; wasn't it?

Mr. JOHNSON. Our station in Hawaii picked it up. Actually that is right. It actually did not pass over Hawaii itself.

I am sorry. It is the station at Hawaii that kept track of it; between Vandenberg and Hawaii we had the 9-minute fix. I am wrong. I shouldn't have said it passed over Hawaii.

Mr. FULTON. And I believe it would be going the hypotenuse of the triangle to Hawaii, so you couldn't just say it is the number of statutory miles to Hawaii when the thing is going up almost vertically.

Mr. JOHNSON. That is correct.

Mr. ANFUSO. Do you have any evidence, Mr. Johnson, whether the satellite is stabilizing or tumbling?

Mr. JOHNSON. Our first information in the first 9 minutes indicates it was stabilized, but we can't confirm it after that.

Mr. FULTON. At the end of the 9 minutes, at what speed was it going?

Mr. JOHNSON. I don't think we have any data on that, Mr. Congressman.

Mr. FULTON. What was your programed power period?

Mr. JOHNSON. 150 seconds in the first stage and about a minute in the second stage.

We got 25,000 feet per second, there is no question about that.

Mr. FULTON. The point I am trying to raise is, there is about a minute less power than we have been usually having in our orbiting satellites; 300 seconds, 303, 315, and this is going about 240, 250, seconds.

Mr. JOHNSON. This is due to the weight of the second stage.

Mr. FULTON. We have an efficiency that is about a 20-percent gain on power time.

Mr. JOHNSON. That is right, sir.

The CHAIRMAN. You reduced your satellite in orbit to two stages, the booster stage and the second stage?

Mr. JOHNSON. That is right, sir.

Mr. DADDARIO. Have you taken steps to inquire of the Smithsonian Astrophysical Observatory of the reasons why they said they could have tracked this vehicle if they had been given 24 hours' notice?

Mr. JOHNSON. Well, yes. We have been in contact with them. I think this was an honest misunderstanding. They did not realize that—we had not informed them in advance that we wouldn't need their services because visual tracking would be impossible. They know this now. At the time they made the statement, I am quite sure they were not aware of that.

Mr. DADDARIO. Do you know if they will issue some kind of a statement so that this confusion which has resulted will be clarified?

Mr. JOHNSON. I doubt if they will. I don't know whether I personally would ask them to. I would presume that the newspaper that printed this—well, certainly we will give them a copy of the statement I just read to you.

Mr. DADDARIO. Because of the fact that there always is in this program accusations made of overlapping and that type of thing, in a statement of this kind, which makes it seem as though one hand does not know what the other one is doing, don't you think it would be a good idea if they would voluntarily come out and make such a statement, since they took the first step to make the charge?

Mr. JOHNSON. Certainly it is a good idea and I will get into the matter and see if this can be arranged.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. The question comes up on the use of your tracking and telemetric equipment. What use was this with regard to the Russian Mechta? How much actual information do we have on that and their claim that it is orbiting the Sun, having gone beyond the Moon, and does anybody have it?

I understand the telescope at the University of Manchester was not even able to pick the Mechta up.

Mr. JOHNSON. I personally believe there is no evidence available to us that this satellite passed the Moon and is orbiting the Sun. We are accepting their word for it.

Mr. FULTON. As far as we know, neither on the U.S. equipment, the British equipment, nor any country of the free world, do we have any firm evidence that it went by or beyond the Moon and is now circling the Sun. I would like to get that in the record because I have been one of the doubters.

Mr. SISK. Would my colleague yield?

Mr. FULTON. Let me have an answer first, and then I will be glad to yield.

Mr. JOHNSON. I personally do not have knowledge of tracking a Russian satellite beyond the moon and I doubt that there is any evidence available to us that it was tracked past the moon.

Mr. FULTON. Would you explain that a little bit to me, that you doubt?

What is the basis of your doubt? I am asking for some affirmative means of identification or tracking and you are saying that there is a doubt.

Was there telemetering equipment aboard and none of us received any signals, or were we unable physically to track?

What is the basis of it? May I ask your associate?

Mr. JOHNSON. Mr. Godel.[2]

Mr. GODEL. The Soviet Union announced the frequencies upon which this satellite was transmitting. A very considerable number of the U.S. stations did receive signals on a number of those frequencies

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[2] Born, Denver, Colo., June 1921. Mr. Godel received his education in Colorado, at New Mexico Military Institute, and Georgetown University School of Foreign Service. He served with War Department intelligence prior to World War II at the beginning of which he was commissioned in the U.S. Marine Corps and served in various command and staff duties in the Pacific. During this period, he was assigned at various times to intelligence and special operations duties in the Pacific and southeast Asia. He is a graduate of the Naval War College and other service schools.

Mr. Godel was retired on January 1, 1947, for disability resulting from wounds received in action. He was recalled from private life in 1948 to accept a civilian appointment with the Office of the Assistant Chief of Staff, G–2, Department of the Army, where he remained until 1950 as a consultant on the U.S.S.R.

In 1950, Mr. Godel was appointed intelligence adviser and Assistant Director for Evaluation and Review on the President's Psychological Strategy Board. In 1951, he was appointed to the Office of the Secretary of Defense where he served as alternate to the Deputy Secretary in his capacity as Defense member of the Operations Coordinating Board. His duties also included intelligence and unconventional warfare activities as they related to the Office of the Secretary of Defense. Mr. Godel was appointed Deputy Assistant to the Secretary of Defense (Special Operations) in 1953, and remained in that assignment until July 1957.

In 1957, Mr. Godel served as a member and Chairman of the Committee of Alternates on a panel established by the Secretary of Defense to conduct an examination of certain intelligence activities and functions within the Department of Defense.

Mr. Godel was assigned to the Advanced Research Projects Agency shortly after its inception as Director of Foreign Programs, and now serves as Director, Policy and Planning Division, for that Agency. In this capacity, he continues his responsibility for oversea activities related to advanced research and is concerned as well with long-range planning, national policy as it relates to ARPA's missions, congressional liaison, and program supervision.

Mr. Godel has, at various times, represented the Department of Defense on intelligence, special operations, and information programs, both in the United States and abroad. He has been a visiting lecturer at the National War College, Armed Forces Staff College, the Naval War College, and other military and civilian institutions.

Mr. Godel is married to the former Joan Mann, of Washington, and has five children.

during the period of the first—my memory isn't very good, but about the time it got to the moon or would have gotten to the moon and could generally confirm that a vehicle—without any knowledge of its configuration—was in that vicinity.

Beyond this, the matter of tracking the vehicle much beyond the first—and my recollection is 30 hours—became extremely difficult for a number of reasons:

(1) The Soviets themselves announced that the vehicle had gone dead and that the signals were no longer being received.

(2) From their point of view, the vehicle was beyond this period not in a position where they could receive the signal. In other words, they were on the back side of the earth.

We have said, I think, that any computations as to what the vehicle did beyond the moon would be computation and not tracking on either their part or ours.

We do not question the computation. The vehicle having gone as far as it did, would in the normal course of events have gone into orbit around the sun.

Mr. FULTON. Did we pick it up at Honolulu or Hong Kong, or Jodrell Bank, which pretty well takes in all sides of the earth?

Mr. GODEL. We picked it up at Hawaii, sir, and I am quite sure that Jodrell Bank did get a signal and the Army Signal Corps picked it up.

Dr. ZIEGLER. Fort Monmouth picked it up too, but we had it for a relatively short time.

Mr. FULTON. Really, the signals that came from the shot were relatively of a short time, none beyond the moon and even if the Russians couldn't get them, none of our own three stations picked them up to confirm what they thought was a physical fact. Is that not right, Mr. Godel?

Mr. GODEL. That is correct, sir, but if it got out as far as we did track it the statement made by the Soviet Union is physically——

Mr. FULTON. Probable or possible, nobody knows, because you don't know why the signals went dead on the Mechta, do you?

Mr. GODEL. They have had notorious experience in having bad signal communications on board their vehicles, sir. I mean they do not last as long as we would like to have ours last.

Mr. FULTON. Could you comment on that a little bit because I would like to hear about some difficulties with the Russian program because all we hear about are their successes. Tell us something that has been going wrong with theirs. Let's hear it.

Mr. GODEL. I can give you this much, sir, just from reading——

Mr. FULTON. You evidently know more than you are saying.

Mr. GODEL. From reading magazines, such as the U.S.S.R. magazine and some of their publications—this is totally unclassified information and simply derived from a perusal of what they have done, one can draw—they have stated, for example, that they have had to fill the interior of their vehicle with an inert gas. Physically filling it with an inert gas would be done to reduce the temperature variation to reduce the drain on their batteries.

Mr. FULTON. So they aren't very good on solar batteries, are they?

Mr. GODEL. I don't think we have any evidence that they have used solar batteries at all.

Dr. ZIEGLER. On Sputnik III they have definitely used solar batteries.

I am with the Signal Corps, Astro-Electronics Division, Fort Monmouth, N.J.[3]

They definitely have had solar batteries on Sputnik III for the purpose of operating part of their equipment and also for research too.

On my trip to Moscow last August, I have seen the models of it, and I have talked with the people who have designed those. There is certainly evidence that they are doing this kind of work.

Mr. FULTON. Up through September of last year the Russians' main reliance on tracking was on cameras used by students and on buildings, hills, and that type; simple visual tracking, wasn't it?

Dr. ZIEGLER. I don't think so. They have, from the very beginning, used a very wide network of amateurs to get readings and electronic tracking and they have increased this and on Sputnik III, with its signal, they surely should have had an opportunity to do electronic tracking.

Mr. FULTON. Yes, but I was saying their main reliance on their early vehicles for tracking was on that type of instrument, simply cameras in the hands of students. As a matter of fact, I heard the Russian representative say at The Hague last September I guess it was, in 1958, that that was their method.

The thing I am trying to bring out is, they are not quite as advanced in many fields as we are, are they, Doctor?

Dr. ZIEGLER. I would say in some details of instrumentation, electronics, they certainly are not, and as Mr. Godel pointed out, they may not have equipment which is as reliable as we would like to have ours to work. This may be true.

If you look at some of the Russian equipment, you come to the conclusion that they just take regular conventional types of equipment and make it adaptable somehow to use in satellites, but they are not developing special type miniaturized and vacuum-proof and radiation-type components as we do very carefully.

This probably is the reason why they take much more weight and are less efficient in using that payload to some extent.

Mr. FULTON. So you would say then on guidance and control equipment that the United States is ahead of Russia, as well as on telemetering and tracking equipment?

Dr. ZIEGLER. I wasn't so much referring to guidance control as electronic equipment carried in the satellite for scientific purposes.

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[3] Ziegler, Hans Konrad, consultant, Power Sources Branch, Squier Signal Laboratories; *residence, 213 Perrine Avenue, Elberon, N.J. Electrical engineer; born 1911; Technical* University of Munich, Germany, B.S. in electrical engineering, 1932. M.S. in electrical engineering, 1934; Ph. D. in electrical engineering, 1936; assistant professor, Electrical *Engineering Technical University of Munich, Germany, 1934–36; research engineer, later* chief of the research and development department of Rosenthal Isolatoren, Ltd. (subsidiary of AEG), Germany, 1936–47; scientific consultant, SCEL, 1947 to date. In Germany: *Research and development in electrical power generation and distribution, dielectrics,* technique of highest voltages, lightning discharge, high current arcs; electrical fuses, electrostatical and acoustical proximity fuses. Various publications and patents in *these fields. With SCEL: Research and development rotating electrical machinery* and related power equipment. Application of permanent magnet material to power equipment. Basic work in new methods in design of permanent magnets, permanent magnet generators and voltage compensators. Member of various professional committees.

Since December 1958, served as Director, Astro-Electronics Division; prior to that as Assistant Director of Research, USASRDL.

Dr. Ziegler's title as of September 1958, Director, Astral Electronics Research (Astro-Electronics Division, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J.).

Born in Bavaria.

Mr. FULTON. On tracking and telemetric equipment, is the United States or Russia ahead in this particular field?

Dr. ZIEGLER. I believe I cannot answer this definitely, Mr. Congressman.

Mr. FULTON. Mr. Godel, can you answer it? In tracking and telemetering equipment, who is ahead, the United States or Russia?

Mr. GODEL. It is not answerable just in one word, I think.

Mr. FULTON. We are able to ask the question in the missile field generally on satellites. Why can't we on this?

Mr. GODEL. I have an answer. There is one fundamental difficulty that confronts the Soviet Union in these deep space activities and this is the problem of geography.

To maintain constant surveillance on a vehicle as it transits the moon and goes beyond, one generally requires ground stations, tracking stations located at as near as possible, 120 degrees apart on the earth's surface. With the free world geography being what it is as compared to Soviet geography, they do have an inherent limitation on their tracking deployment.

Mr. FULTON. How would you describe our deployment then?

Mr. GODEL. Our deployment includes facilities located as far apart as in Australia, up and down the 75th parallel.

Mr. FULTON. Where?

Mr. GODEL. At Romarusa and through North and South America generally along the 75th parallel. We have some stations in Europe, in Germany, microlock stations, and are planning to install a facility in Spain. This has been agreed to. There will be some others as well.

This gives us then effectively a "T" across the earth's surface which will enable us to track on a continuous basis vehicles operating on a near equatorial orbit or on a polar orbit.

Mr. FULTON. You have good facilities for tracking, telemetry, as well as command stations?

Mr. GODEL. There are stations in Alaska, Hawaii, and there are collaborative stations with other countries in Hong Kong and Singapore. Many of them developed as a part of the International Geophysical Year and others developed as a part of the Army Explorer program and still others as a part of the Discoverer program.

These have, as we testified earlier, and as Mr. Johnson testified, been pulled together into a single joint network for the Department of Defense and the National Aeronautics and Space Agency; our purpose being one of establishing, insofar as it is possible, a general purpose worldwide network.

Mr. FULTON. So that really we are coming to the point where we could say that we in the free world, in cooperation with our allies and friends, have a worldwide network of tracking and telemetry stations that the Russians do not have, so obviously we are ahead of it.

Why are you scientists always so afraid to say we are ahead of them? I don't get it.

Aren't we ahead? Say "Yes" or "No."

Mr. GODEL. On tracking, yes, sir.

Mr. FULTON. And telemetry? Say "Yes" or "No."

Mr. ANFUSO. Will you yield there a minute?

Mr. FULTON. I want to pin somebody down for once.

They are so grudging on saying we are ever ahead of them and, boy, let me tell you, this public is after us every time it looks like we are behind.

Mr. GODEL. I don't know what you mean by telemetry, sir. If you mean the ability to generate over a long period of time modulated signals which give us information, I think the answer is perhaps fair that we think our equipment is more sophisticated.

Mr. FULTON. I certainly think it is much better.

Mr. GODEL. Now, the problem is whether what the Soviet Union uses does do the job in the present state of the art and I suspect it does.

Mr. FULTON. Now, let me ask you on a couple more and I will yield completely.

How about on miniaturization? We are tremendously far ahead of the Soviet, are we not, on that?

Dr. ZIEGLER. Yes; that is correct.

Mr. FULTON. You don't have to have a town meeting to decide it. You pass it around here as if it is a hot potato.

I don't know. I think we need a course for American scientists in how to make friends and influence people. They seem to think they are taking advantage of the scientists in Russia somehow.

Let us ask again, on the number of things which we have in the channels within a satellite. We have tremendously more, don't we, than the Russians, say on radiation detection, the equipment for meteorological and weather purposes?

Mr. GODEL. I would think not in this case, Mr. Fulton.

Mr. FULTON. Where do we lack there?

Mr. GODEL. We have tended, partly as a result of propulsion problems and partly as Dr. Ziegler has indicated, because of a desire for sophistication, to limit the number of discrete experiments in a given flight. The Soviet Union, in Sputnik III, for example, announced, oh, 15 or 18 separate experiments as being contained within the single chamber.

We have perhaps not gone as far toward multiplying the number of individual experiments in a given vehicle, that is right.

Mr. FULTON. You have certainly done more, say, on the Van Allen radiation belt than they have.

Mr. JOHNSON. I think that is right.

Mr. GODEL. Presumably so; yes, sir, I think that is right. We aren't really very clear on how much they may have done on this at this time.

Mr. FULTON. I yield.

The CHAIRMAN. Of course, one of your great difficulties is the fact that the Soviets don't tell you clearly and with candor what advances they have made every time they make an advance or a detection or invent something. That is correct, isn't it?

Mr. GODEL. They certainly don't say as much as we do, sir.

The CHAIRMAN. It places you at a disadvantage in making a comparison. You know what we have and you don't know entirely what they have.

Mr. Anfuso.

Mr. ANFUSO. I would just like to add to what the chairman has said, that you scientists would like to be as optimistic as you possibly

could, but you don't have available certain classified programs which the Russians just won't tell you about.

Mr. GODEL. That is right.

Mr. ANFUSO. You gather all the information you can from books, as you say, but other doors are closed to you.

Mr. GODEL. I think Mr. Johnson once said in response to that question that we generally know substantially more than the cynic thinks we do and substantially less than we would like to know.

Mr. FULTON. How many places are you set up in the world for command control on missiles or satellites?

Mr. GODEL. I think, sir, we would rather discuss that in executive session.

Mr. JOHNSON. That is classified.

The CHAIRMAN. Any further questions?

If not—have the statements arrived at all that we were waiting for? If they have, distribute them.

Mr. JOHNSON. I have a statement, Mr. Chairman, which was just finished.

Mr. FULTON. May I compliment your team? I think you are a fine group and we wish you all the best. I have been with you on some of the experiments and I think you have been doing a wonderful job. Even though you won't say anything about it.

Mr. JOHNSON. Well, Mr. Congressman, I think perhaps the attitude of most people in this work is; we would rather run scared than the other way. I think our posture for the future would be better if we erred on the side of running scared than assuming that we are superior to the Russians. Maybe we are wrong in that posture.

Mr. WOLF. That is a very fine statement.

Mr. FULTON. May I just say this to you: The contrary to that is, you scare the public to death by making them think Russia is ahead of us in every field when there are certain fields where we are obviously ahead of the Russians and it looks as if, to many people, that their homes, their lives, their families are in danger because of the reticence of the U.S. scientists to speak up and say what they have done.

Now, maybe I am going to be in the school that says we should give more information. In the bill that we passed last year, one provision proposed by many of us on the Select Committee on Space and Astronautics, said that our aim in the United States should be to make public these scientific facts of discovery in the space field, really for the benefit of the whole world.

I would finish off by saying that when there are no obvious military applications on many of these things, maybe we would be further ahead in the estimation of the American people and of world judgment if we were more open—we would be the open one and let Russia be the secretive one that they are worried about.

Mr. ANFUSO. Would the gentleman yield?

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. I would like to say to the gentleman from Pennsylvania that he is certainly sincere in his outlook on this subject and he is one of the most valuable members of this committee, but I have said time and time again in this committee that we should tell the public a lot more than we perhaps are telling them and we should not be too optimistic.

I would rather see the public scared because a public scared will give us the money to do the job—will give you gentlemen the money to do the job and it will help this country in the long run.

Mr. FULTON. Will my good friend yield?

Let's don't scare them around election time. That is the point.

Mr. ANFUSO. But if the country takes the attitude that everything is going well, well then there is no reason for all of these appropriations. Let us cut down on them. Let us balance the budget. Let's do all those things. That is the way the public will answer you.

And frankly, Mr Fulton, I am not talking about election time. I will say this the day before election and I will say it at any time during the year.

The CHAIRMAN. Perhaps, since everybody is "popping off" a little bit, I ought to say something.

My own judgment is perhaps tempered by 22 years on the Armed Services Committee, and I don't believe in the space age there is any second place in a war between two major powers. I think you either win or you lose and if you are behind—if you think you are ahead and you are not ahead, you may come in second, and there is no room for second place.

Mr. FULTON. But certainly, Mr. Chairman, if you would yield, this committee has jurisdiction of the entry into space by peaceful means and to use it for peaceful purposes.

Certainly there is room enough in space for some peaceful purposes, too, and scientific advancement for the benefit of the world. It can't all just be aimed militarily.

The CHAIRMAN. We would prefer it all be for peaceful purposes.

Now, will you proceed with your statement, Mr. Johnson?

Mr. JOHNSON. Gentlemen, I welcome this opportunity to discuss with you today our program in the field of communication satellites for military services.

I should like to emphasize first that this is a military program that we are discussing today. There will undoubtedly be elements and gains made through this program which can provide rakeoffs to the civilian communication needs, but it is a program specifically tailored to the more rigorous military requirements of reliability, security, and resistance to interference and to jamming.

Our objective in this program is to provide an integrated, secure system of military communications. It will operate under any anticipated conditions against any interference, either manmade or natural, providing three types of services.

First, there is communications between any point on the surface of the earth, including the polar regions.

Second is communication between any point on the earth's surface and aircraft or ships.

Third is a broadcast service whereby military information or orders can be transmitted to all military elements. Each of these three services is required on an instantaneous basis.

The requirements to which our program is tailored are stringent. It must provide complete reliability at all times. For certain critical strategic intelligence information or when command control at the national level is involved, we must have communication facilities which can transmit messages between any major command elements anywhere in the world in a matter of a few minutes at any time.

Present communication facilities do not meet this criterion.

Secondly, we must have communications which are able to handle the most critical traffic under conditions of interference or jamming, either natural or manmade without delay.

Present systems do not meet this requirement.

Our present military electrical communication systems depend on either radio or cable. Cable is subject to sabotage or outage from natural causes. We have been reading in the newspapers, for example, the Bell cable across the Atlantic and four Western Union cables were out for over a week. Radio, other than short range, falls into three general categories for the purpose of this discussion.

For long-haul circuits, we use high-frequency radio circuits. These can communicate at any range around the world, but the reliability is low—50 to 90 percent—decreasing with distance from the equatorial regions. This low reliability results from many natural factors such as sunspot activity and changes in the ionosphere. These figures do not consider the possibility of enemy jamming which will further reduce the reliability.

Tropospheric and ionospheric scatter among the circumstances have greater reliability and greater traffic capability, but their range is inherently limited to approximately 600 and 1,200 miles, respectively.

There are a number of types of traffic which must be carried by military communication facilities. The precise volume of this traffic is, of course, classified.

To meet these requirements, we have worked out a program of communication satellite development which is shown on this chart [indicating].

Communications satellite program

Project	Type	Scheduled research and development completion date
Score	Delayed repeater	December 1958.
Courier	do	June 1962.
Polar communications	Real time repeater	Do.
24-hour equatorial	Real time fixed repeater	June 1963.
Long-range program	do	June 1968.
Basic research		Continuing.

I will discuss each of these elements in some detail.

First in this area was Project Score which successfully put a delayed communication repeater in orbit with an Atlas vehicle last December 18. This was a rudimentary form of the device which will be improved greatly in the Project Courier, No. 2 on the chart whose development is scheduled for completion in 3 years.

Project Courier—we are working on a polar communication system specifically to meet the requirement for communication with aircraft in the arctic regions. The development phase is scheduled for completion in 3 years. We are scheduling satellites such as Discoverer in polar orbits in order that we may learn any peculiar problems which may exist.

We have under development a more advanced communication system employing a Stabilized equatorial orbit. We expect to complete research and development in 4 years.

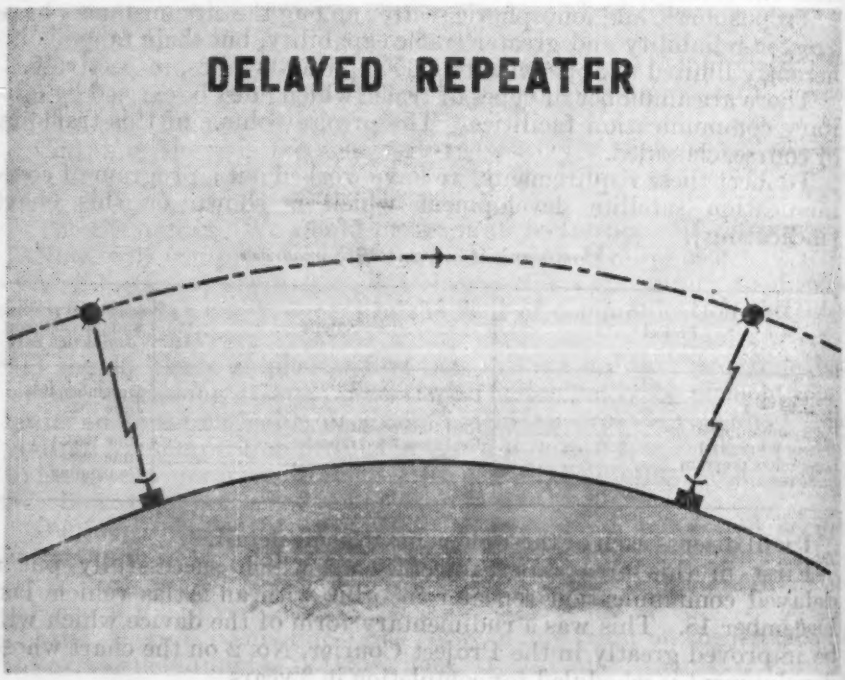
We have in development a new booster with considerably greater thrust—the 1.5-million-pound engine with appropriate upper stages in which you have already been briefed. We expect to develop a much better communication system using this booster than we can with those now available.

With a considerable relaxation of weight limitations, tremendous improvements will be possible and I will discuss this later.

The last item in our program is that of research to support the long-range military communication developments. This research is directed toward reliability, resistance to jamming, low detectability, development of required components and materials, and a study of environmental factors which affect our program.

Let me now discuss each of these elements of the program in some detail. I will omit discussion of Project Score since that is completed. It was a system of limited capability put together in a short time to prove a concept. In this it was successful.

Now, the next chart.



The Courier concept is shown on this chart as a satellite at relatively low altitude passing over a ground station, information previously stored in that ground station is transmitted rapidly to the satellite, where it is stored on magnetic tape. As the satellite arrives in the area where it can be seen by the station to which the traffic is addressed, that ground station transmits a securely coded command to the satellite, directing it to transmit the stored traffic.

While the ground station is receiving messages addressed to it or through it, it may also be transmitting on a different frequency traffic to be carried by the satellite to other stations; by transmitting at very high rates during this short time that the satellite is in view of

each station, we are able to have a traffic-handling capability equivalent to 20 continuously operating teletype channels each of 100 words per minute.

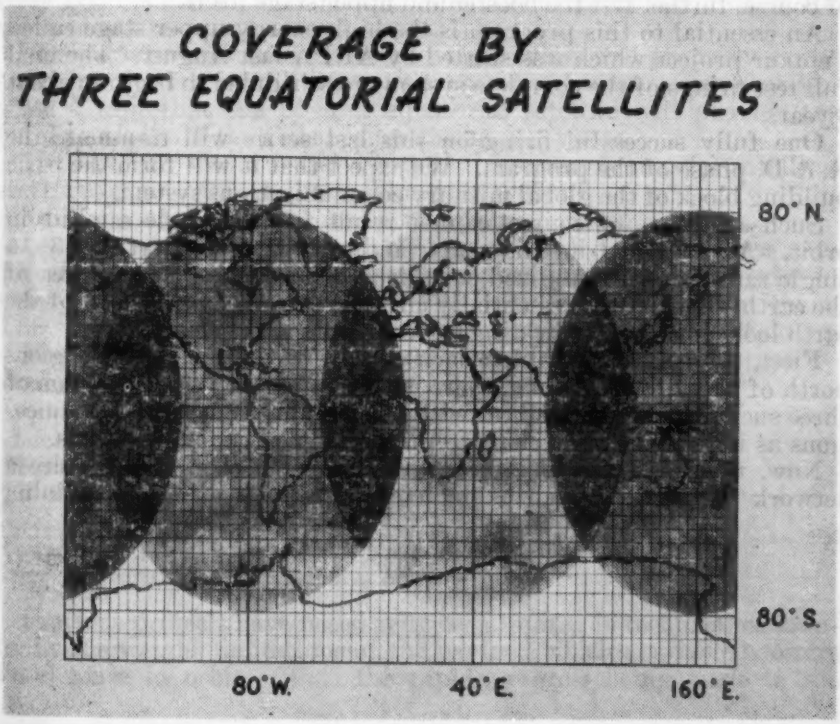
We are planning the first firing of this system within a year. As each shot goes into orbit, it will be subjected first to a period of R. & D. testing to determine improvements which should be worked into later tests. Each satellite will then be made available for operational testing to derive experience based on actual usage. The benefits of both types of use will be plowed back into the program.

We expect that the system will become operational about 6 months after the third firing.

The second program which we are now pursuing as a matter of considerable urgency is one to provide communications between ground points in the United States and aircraft in the polar regions about which I can testify in further detail in executive session. We plan to make a test firing to put a satellite in orbit for this purpose in 2 years and to complete all development work in 3 years. To meet operational requirements, of course, more than one satellite in orbit will be required in order that one shall be available at all times in the region where it is required.

A more sophisticated system and one which we feel is the real answer to rapid, reliable military communications, is the 24-hour equatorial time repeater—real time repeater.

This satellite, at a distance of 19,400 nautical miles from the earth, travels in its orbit at a speed such that the rotation of the earth keeps the satellite fixed with respect to any point on the earth. As may be seen from this chart [indicating] from this great distance—about



three times the diameter of the earth, a large portion of the earth's surface is visible from the satellite at one time.

It can thus provide a relay between points separated by several thousand miles. The characteristics of this communication package are indicated in the next chart.

24-hour equatorial real time repeater

Altitude	nautical miles 19,400
Frequency	megacycles 2,000
Power output from satellite	watts 20
Power output from ground	watts 1,000
Power output from aircraft	watts 100
Equivalent capacity	voice channels 144
Weight in orbit	pounds 625
Satellite or aircraft antenna	foot dish 2
Ground antenna	foot dish 28

This equipment will be heavier than the earlier packages. It will also have a much increased communication capability: 144 voice channels as compared to 20 teletype or 1 voice channel. It will provide this service on an instantaneous basis between the points being linked.

In addition, it will have equipment for one voice channel for use to aircraft. It will provide greater security and resistance to interference. The development schedule for this project provides for initial firings in a year and a half, and to test various subsystems individually.

These will intensify the attitude sensor and control system which will keep the attitude pointed toward the earth. They will go on to test the power system and communication antennas. They will also, of course, further test the booster and upper stage itself.

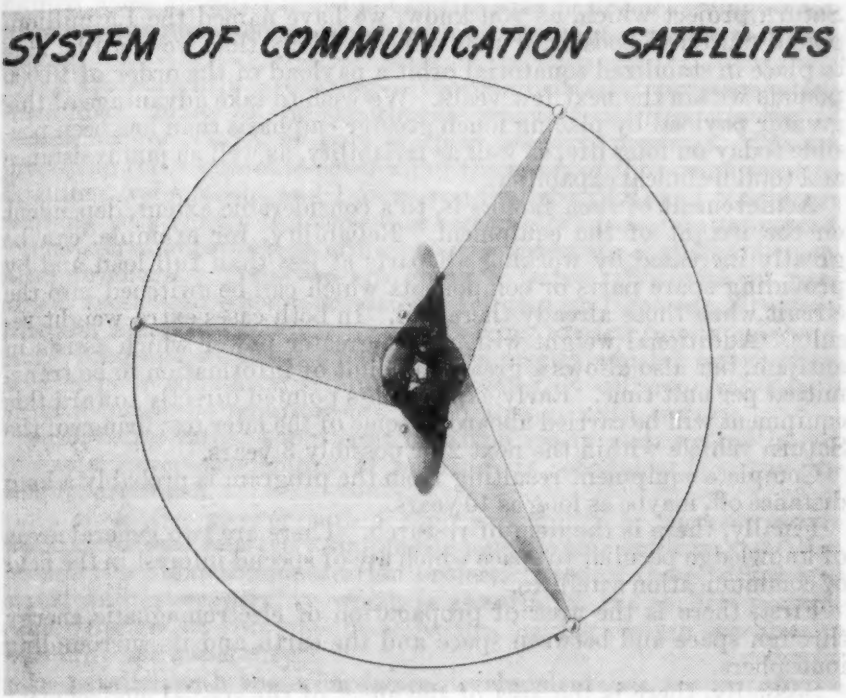
An essential to this program is the high energy upper stage called Centaur project which was started by ARPA last August. The final full test firings of the complete system are scheduled to begin in about 3 years.

One fully successful firing on this last series will terminate the R. & D. phase of the program. We expect that it will form the basic building block of the global military communications system.

Such a system, of course, cannot result from a single satellite in orbit. As indicated in this chart [indicating] (see chart No. 3), a single satellite in a stabilized equatorial orbit can see a large area of the earth. This area is essentially circular but a flat projection of the earth looks like this [indicating]; two factors are evident.

First, there is the complete lack of coverage in the polar regions north of about 80°. Second, there is a requirement for a minimum of three such stationary satellites with overlapping zones of communications as indicated on the chart to provide global communications.

Now, to meet the full military requirements then will require a network of satellites such as depicted here [indicating], combining



both equatorial orbits and polar orbits. Using such a network with relay from one satellite to another when required, we can provide for any military communication requirement.

The package provided for each of these orbits will probably be the same, but the orbits will differ. This is what I meant a moment ago when I said that the 24-hour equatorial satellite will provide the building block for the global communications system.

Mr. FULTON. Could I ask you, does that mean four polar satellites and three equatorial satellites making the system?

Mr. JOHNSON. Yes, that makes the system. Seven satellites.

In order to achieve a reasonable degree of economy, we must gain considerable experience at accurately controlling satellites in orbit in order that they may be placed in fact, as we indicate on that chart. This, I feel confident we can do, but it is going to take a lot of doing.

The final equipment development which I shall discuss is that indicated on the next chart.

Long-range program

Altitude	19,400 nautical miles.
Frequency	Probably 2,000–2,300 megacycles.
Power	150 watts.
Equivalent capacity	300 voice channels or 2 television channels.
Weight in orbit	8,000 pounds.
Ground antenna	28-foot dish.

Previous projects have necessarily been limited in technical capability by the weight limitations of the payload which available boosters could place in orbit. With the rapid progress being made in the

Saturn project which, as you know, we have named the 1.5 million-pound clustered booster, it now appears likely that we shall be able to place in stabilized equatorial orbit a payload of the order of 10,000 pounds within the next few years. We wish to take advantage of this greater payload by placing much greater emphasis than has been possible today on long life, as well as reliability, as well as jam resistance and total technical capability.

Achievement of such factors is, to a considerable extent, dependent on the weight of the equipment. Reliability, for example, can be greatly increased by working all parts at less than full load and by providing spare parts or components which can be switched into the circuit when those already there fail. In both cases extra weight results. Additional weight will permit greater power which assists in antijam, but also allows a greater amount of information to be transmitted per unit time. Early experiments pointed directly toward this equipment will be carried aboard in some of the later test firings of the Saturn vehicle within the next 2 or possibly 3 years.

Complete equipment resulting from the program is probably a long distance off, maybe as long as 10 years.

Finally, there is the item of research. There are two general areas of knowledge peculiar to space which are of special interest in the field of communication satellites.

First, there is the area of propagation of electromagnetic energy through space and between space and the earth and its surrounding ionosphere.

Secondly, there is the area of the effect of the special environment on electronic—of the spatial environment on electronic equipment. In the first area we have learned something through the experiments which have been conducted to date with communication satellites and with various transmitters for other purposes such as telemetry and tracking of satellites.

However, these experiments have, in the interests of both time and economy, employed frequencies for which existing ground stations were equipped and for which electronic components are already available. There is much to be learned about the effect of high altitude on propagation. We have had no experience in propagation between earth and space in the polar regions.

What we need is complete information of the propagation characteristics of the electromagnetic spectrum as it relates to the atmospheric and ionospheric conditions, auroral disturbances, position, and many other conditions in space.

In the second broad area, that of the effect of spatial environment, there is much to be learned, especially as we go toward communication satellites with greatly extended useful life—indefinite life. We know a great deal about the energy distribution of solar energy in the visible and the infrared regions, but we need to know much more about the ultraviolet and soft X-ray region. We need to know much more about long-term variations in these factors, during periods of solar storms, for instance.

Charged particles and cosmic radiation may materially affect the life and effectiveness of our communication satellites.

I am not trying to outline the program in detail but merely to indicate the many areas of uncertainty which must be filled in. The

limited work already carried out in this area has been serving to emphasize to us the extent to which we must obtain much more information.

We are currently preparing a thorough detailed program along these lines. Many of the experiments which we will require will be performed by NASA as part of their research program. We are preparing the program to cover all of the needs of the communication satellite developments, and I assue you that the DOD and NASA are working very closely to insure that research is adequately supported.

The communications satellite program presents challenging technical problems. These we are going to solve. We wish to have an advanced secure communication satellite with large capacity, long life, and reliability. While we are working toward this in our long-range program, we are also pursuing the project which I refer to here as a 24-hour equatorial satellite, but even this will require about 4 years to meet the requirements which already exist today.

Also, being rather sophisticated, which really means complicated, it has a lower probability of meeting its schedule than does the simpler approach.

As an earlier answer with a high probability of success, we are working on two relatively simple communications systems, the Courier and the Polar communication project. Each of these will give us a real military capability which is essential at the earliest possible time. But to get this timeliness, we are making certain sacrifices in flexibility and capability.

In parallel with these hardware developments we are pursuing a research program which will contribute to the long-range program. It will make its greatest contribution, however, to projects not yet conceived.

Thank you very much for this opportunity to discuss the program with you. I shall be very happy to entertain any questions which you may wish to pose at this time.

I would now like to introduce Mr. Paul A. Price, formerly Assistant Chief of Research and Development of the Army Signal Corps who has been assigned to ARPA as the technical project officer for ARPA's communication satellite program.

In addition, we have Dr. Hans Ziegler, the Director of Astroelectronics of the Signal Corps Laboratory at Fort Monmouth who has overall technical supervision of the communication payload of our program.

These two gentlemen are here and are prepared to answer your technical questions.

Thank you, sir.

The CHAIRMAN. Thank you very much, Mr. Johnson. Yours has been a very, very fine statement.

As I looked at that chart in reference to the needed satellites, was there any difference in altitude between the polar satellites and the equatorial satellites?

Mr. JOHNSON. Mr. Price will take over.[4]

Mr. PRICE. Yes, sir. The polar satellites are approximately 5,000 miles. The equatorial satellites will be approximately 19,000 nautical miles.

Mr. BROOKS. Why the difference?

Mr. PRICE. At 19,000 these will be fixed with relation to a point on earth and as the earth revolves the satellite keeps going around at the same time. Therefore, we have a fixed position.

The CHAIRMAN. What about the polar satellites?

Mr. PRICE. This revolves—as the earth revolves this way, the plane also revolves around, so we have to keep the satellites going around so we will have coverage in the northern hemisphere.

The CHAIRMAN. Satellites make a complete orbit of the earth and the equatorial satellite simply maintains a relatively stationary position.

Mr. PRICE. That is correct.

The CHAIRMAN. That is the need for the difference in altitude.

Mr. PRICE. In other words, we have a lower altitude and can use a smaller package here. There is less weight and less power required.

The CHAIRMAN. Do I understand this whole program is under ARPA?

Mr. PRICE. Yes, sir.

The CHAIRMAN. So you consider it of a military nature?

Mr. PRICE. Yes, sir.

The CHAIRMAN. And there is no civilian counterpart to this program?

Mr. JOHNSON. You are, I understand, receiving testimony from NASA tomorrow on a civilian counterpart.

The CHAIRMAN. So we have two programs, as it were, running parallel, one civilian and one with a military tinge to it?

Mr. JOHNSON. The basic data, as I referred to in the latter part of my paper, that we will need for the long range is the work of NASA. We work together in our requirements in this field. We are not duplicating each other, in other words, in this basic research.

In the hardware stages there will be two separate programs. The military hardware is a distinctly different kind of a hardware program than a civilian one would be.

The CHAIRMAN. I am not critical. I just want to get it in my mind. So that although you are running in a sense two parallel programs, you have zoned over the area of activity, even within those programs

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[4] Mr. Price was born in Pittsburgh, Pa., on January 27, 1913. He attended grade and high schools in Bellevue, Pa., and received his B.S. degree from Pennsylvania State College in 1936. In 1939–40 did graduate work at the University of Pittsburgh in mining engineering. Took 1-week course, special weapons orientation, Sandia Base, N. Mex., in August 1955, and 3-week course in command management at Fort Belvoir, Va.

From 1936 to 1941 he worked as vice president and manager of a wholesale electrical supply company in Pittsburgh, Pa. Since that date he has served continuously in the Federal Government in increasingly responsible managerial and engineering positions. His last 8 years were spent in the Office of the Chief Signal Officer, U.S. Army, culminating in the position of Assistant Chief of the Research and Development Division from 1957 to 1959. During this period he received two certificate of achievement awards for outstanding performance of duty.

Memberships include the Association of the U.S. Army, the Armed Forces Communication & Electronics Association, and Sigma Alpha Epsilon. He is a licensed professional engineer in the State of Pennsylvania.

Mr. Price resides in Annandale, Va., with his wife, the former Veronica Marotti, and two children. His hobbies include small-boat racing and he served as secretary of the Capital Power Boat Association in 1956.

Mr. Price now holds the position of Chief, Communications and Facilities Branch, Technical Operations Division, Advanced Research Projects Agency.

so there will be the least amount of duplication and overlapping, is that correct?

Mr. JOHNSON. That is correct, sir.

The CHAIRMAN. How important do you consider this program, sir?

Mr. JOHNSON. We have a letter from the Joint Chiefs of Staff that was some months in the making which establishes this requirement on a very, very high priority. Along with another program which we consider equal to it, but there is no program that has a superior priority to this one.

The CHAIRMAN. About how much money are you spending in this program? What is budgeted this year—really appropriated this year and what is budgeted for next year in it?

Mr. JOHNSON. The budget for next year, as I recall, is $60 million, but this does not include the basic work that is being done on the million and a half pound thrust engine or on the upper stage Centaur which are important parts of the program.

I could give you a figure for the record when I return to the office, of what the total might be, but off the cuff I couldn't give you a total.

The CHAIRMAN. Of course, in a sense the million and a half pound thrust engine would be available for any program?

Mr. JOHNSON. That is right, sir.

The CHAIRMAN. In a sense it is apart from this particular program. In another sense you are relying upon that to get the thrust you need to start this program.

Mr. JOHNSON. Sir, I can answer the question this way: In August of last year, when I issued orders for the development of the clustered engine, it was to fulfill this specific military requirement. To get a payload of the size we needed into the 24-hour orbit—to get the reliability, to get the long life, to have indefinite life batteries, in effect, or rechargeable batteries, this kind of engine was needed.

Since that time it was determined that this basic engine will be used for many, many other purposes.

The CHAIRMAN. Now, how much did you say that we had available this year for spending?

Mr. JOHNSON. The budget for 1960, for just this communications project, is roughly $60 million. We are spending $15 million in fiscal year 1959.

The CHAIRMAN. Well, will the budget amount increase in the years ahead? It is expected that will be the case?

Mr. JOHNSON. I would guess that our effort will peak in about 3 years from now, and would probably be over 100 million dollars per year.

The CHAIRMAN. That would put you in line to show some definite accomplishments at that time.

Mr. JOHNSON. I would hope that within 3 years there would be a payoff on an interim basis, giving the military commands a far greater communications reliability than they now have.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. As far as you know in the plans for systems of communications satellites we have plans that are much more advanced than Russia has. As far as you know, we are the only ones who are going into such an extensive system of worldwide communications satellites?

Mr. JOHNSON. Well, Russia, to my knowledge, has made no announcements at all in this area. I have no knowledge that they are working on communications satellites.

Mr. FULTON. At the present time there is no need for any scientific breakthrough, but simply for the working out of problems which you can foresee answers to; is that not right?

Mr. JOHNSON. That is right.

I think that much of the space work that we are doing is a straightforward engineering job. I think that we have overemphasized the science aspects of the space work.

Mr. FULTON. So far as you are doing research and development in this particular field, when you once get it established, you are in business, you have produced and it is accomplished, is that not——

Mr. JOHNSON. Every program we have in DOD is oriented toward producing specific hardware which we visualize before we start.

Mr. FULTON. When you get these satellites in the air as you progress, you actually are not only doing the research and development, but you are also accomplishing the results of production. You have the end result right there in this particular instance, don't you?

Mr. JOHNSON. That is right.

Mr. FULTON. May I ask you on your method of calculating distances—you have been speaking of a distance of 19,000 miles. Is that a distance from a perpendicular from the nearest point on the earth's surface or is it a distance from a tangency on the horizon or from the center of the earth? Where is the distance from?

Mr. PRICE. That is from the surface of the earth. It is six times the earth's radius.

Mr. FULTON. So it is 19,000 miles. I would have said it was between 22,300 and 23,000 miles from the surface of the earth.

Mr. PRICE. Those are statute miles, and I was referring to nautical miles.

Mr. FULTON. These will be nautical miles then and they are from the surface of the earth.

Mr. PRICE. That is right.

Mr. FULTON. That is all.

The CHAIRMAN. Questions?

Mr. Sisk?

Mr. SISK. Are we going into executive session this morning or not?

The CHAIRMAN. It depends on whether we finish up. Will you gentlemen be available tomorrow morning?

Mr. DUCANDER. We have other witnesses tomorrow morning.

The CHAIRMAN. Then we will have to finish up today with these witnesses.

Mr. SISK. I have just a couple of questions. I understood there was certain information here which was pretty much borderline, and I certainly don't want to get involved in anything that would be classified as a military secret, of course.

To pursue a little further questions by my colleague from Pennsylvania, Mr. Fulton—and sometimes I wonder, you know, if we may not be whistling in the dark a little bit sometimes, you know—actually the facts are, as I understand you to indicate, that much of this today is an engineering problem.

In other words, the pure science itself has in certain instances been accomplished, and so it becomes an engineering problem to develop the hardware and so forth. Is that right?

Mr. JOHNSON. That is right.

Mr. SISK. Certainly I would hope that we were well ahead, but of course in view of the fact that I think we have underestimated potential enemies before, would you not agree that it would be better that we do not underestimate them again, not only in this program, but any other program with which we are concerned?

Mr. JOHNSON. Well, I certainly feel that we should not make the mistake that was made in the middle forty's that caused delay in the missile program.

Mr. SISK. That is the point I am making. In other words, we underestimated at the time.

Mr. JOHNSON. That is right. We underestimated the need for and the capability of firing rockets.

Mr. SISK. And our knowledge of what they may be planning in the communication fields, or many of these engineering fields, is something of which we are not aware because they do not reveal their plans and programs and future designs to us, isn't that correct?

Mr. JOHNSON. That is correct.

Mr. FULTON. Would you yield?

Mr. SISK. Yes; I will be glad to yield to the gentleman. In view of the fact that I mentioned whistling in the dark and I do not accuse the gentleman of doing that, but some of this sounds a little bit like that.

Mr. FULTON. I will say this: You are well pleased, are you not, with the developments that you in your particular field of ARPA are making on the communications satellites, on the polar shots, on the proposed setup of systems for equatorial satellites—you are well satisfied, aren't you?

Mr. JOHNSON. I am, sir; yes, sir.

Mr. FULTON. Are the others satisfied?

Mr. GODEL. Yes.

Mr. PRICE. Yes, sir.

Dr. ZIEGLER. Yes.

Mr. FULTON. On the system of equatorial firings, you would then not try to take an equatorial firing pad from Canaveral and try to stabilize it on the equator; you would rather shoot from the equator, would you not?

Mr. JOHNSON. That is right; it is less complicated.

Mr. FULTON. Then you would be trying for a circular orbit so it would have a constant speed, rather than have an orbit that has various speeds?

Mr. JOHNSON. A satellite kept in constant orbit is a neat trick because it would drift. It would have to have something to give it a shot now and then to kick it back where we want it. This is not a simple straightforward job. I still insist it is an engineering job, but it is not an easy one.

Mr. FULTON. Then to see where you would originate the shot from, it would not be from Canaveral, nor would it be from Vandenberg Field.

Mr. JOHNSON. It could be from Canaveral, but my guess is when we get around to this, it will go from an island on the equator or near the equator.

Mr. FULTON. So if you look at the Galapagos, it would go toward the east, would it not, and that would bring it over Mexico?

Mr. JOHNSON. It has to go to the east, but it could go to one of the islands, Kwajalein, or one of the ones out there.

Mr. FULTON. Or it could be an island just off Brazil where we have an arrangement, or Ascension Island in the Atlantic.

Mr. JOHNSON. I think the amount of water you would have to travel over as opposed to land may not make that as desirable as a Pacific spot.

Mr. FULTON. How about Christmas Island that the British have? Would that be a good island?

Mr. JOHNSON. It might be perfect if arrangements could be made with the British; yes.

Mr. FULTON. You might like that better than any of these other islands we have spoken of.

Mr. JOHNSON. I think that is right.

Mr. SISK. Is the gentleman finished?

Mr. FULTON. Would you object if this committee makes a recommendation that we ask the British to consider Christmas Island?

Mr. JOHNSON. Please, sir, don't take my statement that this is the most desirable location. I would like to say that we have not finished our studies on the spot.

I suspect that our first attempts may well be from Canaveral, but we will have to sometime in this program have an equatorial island. Whether Christmas is the best, I wouldn't want to say today.

Mr. FULTON. I am also a member of the Foreign Affairs Committee, and we might be able to help you out a little bit.

Mr. JOHNSON. We may call on you.

Mr. SISK. If I may now have the the floor back, I was going to suggest maybe you should take that back to your other committee.

I would like to inquire, Mr. Johnson—I don't know to what extent you would want to comment on this, but in view of the fact you mentioned this morning, there are going to be pure military launchings in the future because of the type program you are involved in, certainly that is going to lead us then into this field where there are certain implications involved in the so-called space law.

To what extent is ARPA or Department of Defense or anyone, let's say in your particular area of this field operation, doing any research work or developing answers we may have to give sometime in the field of space law and its implications, when we go to strictly military launchings as against geophysical year activities and so on?

Mr. JOHNSON. There is a study group headed up within the State Department and in which the DOD is represented, and other agencies working on this. It was discussed as recently as yesterday. There are no conclusions. This is a very difficult matter. I think premature statements on basic space law would be undesirable. I think this is about the only conclusion that a lot of us have come to at this point.

We have much more to learn yet about the uses of the space beyond natural atmosphere before we are ready, I think, to talk about the law. But there will be a point when this will be necessary, but it is early.

Mr. SISK. It is possibly true that this is early, but certainly we have had testimony before this committee, and probably maybe from you people, that it is not at all impossible in the near future—and by near future I mean within the next few years—that these satellites may be able to be neutralized through what might be called defensive action or enemy action or something of that kind. When we start talking about strict military launchings, I think we are moving into a field, of course, where we shouldn't delay too long in coming up with some answers about what we are supposed to do.

The CHAIRMAN. Will the gentleman yield?

Mr. SISK. I will be glad to yield.

The CHAIRMAN. At the end of this week we propose to have two hearings on space law. That is the beginning of what we are doing. We have them organized. I don't know what will develop at this time, but really the gentleman is correct in the thought that we should give that some attention.

Mr. JOHNSON. I have one word of caution here. I think the mission of the satellite is important. As long as the mission of the satellite is not to impose physical injury or harm, I presume the freedom of the seas concept would obtain. The problem here is how do you inspect a satellite to determine whether it is capable of harm?

And again I don't think that you can go further in this area until a technically feasible inspection system has been worked out. This is going to take an awful lot of doing.

It is the same basic problem that we have in ceasing atomic energy testing.

Mr. SISK. I agree with you, Mr. Johnson, certainly that it does have tremendous difficulties involved when we anticipate some of the things that could happen in the field. Of course, whether a satellite might prove harmful, I am thinking of satellites of the nature of reconnaissance and so on, which become indirectly harmful or might be unwanted by potential enemy countries or something of that kind.

Mr. JOHNSON. It is my opinion that the very posture of our country in the world scene demands that we go very slowly here. I believe we have more to gain in this program than other nations might and therefore we have less to gain by running fast into a space law exposition.

Mr. SISK. I am inclined to agree with you on that.

The CHAIRMAN. Gentlemen of the committee, it is now 11:30. We have been told a good deal of the information to be given us has to be given in executive session. Unless there is some objection, I would suggest we go into executive session now.

We can continue until noon and perhaps finish up this particular program of these witnesses this morning. Then we will meet tomorrow morning at 10:30.

Is there any objection? If not, the committee will proceed to go into executive session.

(Whereupon, at 11:25 a.m., the committee proceeded in executive session.)

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Tuesday, March 3, 1959.

The committee met in executive session at 11:25 a.m., in room 359, House Office Building, the Honorable Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee is in executive session and you gentlemen may proceed to tell us what you have in mind in executive session as quickly as possible. Perhaps we can finish up by 12 or just a little after 12.

STATEMENT OF ROY JOHNSON, DIRECTOR, ARPA

Mr. JOHNSON. * * *

I think at this point it is important to point out that if there is any inclination to say that communications are communications and you can combine military and civilian and RCA and so forth as some people might propose, that we have to be very careful to make sure that the military communications system is reliable at all times, that it is failproof, that it is jamproof. It has a must stiffer criteria than any civilian system that could be developed.

This may be the one point in the total space effort where some members of this committee might say there is duplication between what NASA is doing and what the military are doing.

This would be very unfortunate if there should be any attempt here to, for reasons of economy, to begin consideration of a common communications program.

The CHAIRMAN. Well, I think it is important that we do proceed with this, that even a little duplication might well be overlooked. This is extremely important, I think.

Mr. JOHNSON. This is my great concern.

Mr. ANFUSO. I would concur.

The CHAIRMAN. Mr. Johnson, what assurance have we now that when we have finished this setup and we are ready to operate, what assurances do we have that is going to work?

Mr. JOHNSON. Well, this is a mathematical thing depending entirely on the state of the art as we know it now.

I believe that there is nothing really new that we have to invent. Now, Dr. Ziegler and Mr. Price can answer that better than I can.

Are there a lot of new things we have to invent to do this?

Mr. PRICE. Basically, there are not a lot of new things. I think that the best example of this was Project Score. This used what we had then. We had practically 100 percent certainty as far as the electronics were concerned that it would work, and it did.

If we look into the future one time here, there are some components and things like that where we know the basic laws of what to do. We havent made it into a hardware stage, yet. I think this is the primary thing.

Dr. ZIEGLER. I certainly agree. I may stress one incident too much, but I would just like to mention, when we had operation on the Score

project for several days, we were permitted to take the President's message off and put something new on. We had an open telephone line to California and we were all ready to put the new message into the satellite and the satellite was operating perfectly. We had complete communication to all the three ground stations near California, but the ground telephone line to California broke down and we were not in a position to do it on this particular orbit and we had to go around in orbit and lose one complete round.

At this early stage, the single-hop connection to the satellite was more reliable than the telephone lines which have been highly developed over the years which we have on the ground.

I would like to mention something which probably bothers many people in their mind and that is can we afford to put very sophisticated and expensive equipment up here without knowing how long it will live up there?

The CHAIRMAN. That was going to be my next question, as to how long it will last when we do get the system working?

Dr. ZIEGLER. Here again I would say we don't have all the answers, but we have very encouraging results here. We will have an anniversary in 2 weeks on St. Patrick's Day when Vanguard No. I, that little grapefruit which was considered so insignificant, will operate for a full year on solar batteries and transistorized transmitters.

Mr. JOHNSON. That is Dr. Ziegler's baby.

The CHAIRMAN. Is that still operating, the Vanguard?

Dr. ZIEGLER. It is still operating as it was on the first day.

The CHAIRMAN. You are still getting the signals?

Dr. ZIEGLER. Excellent.

The CHAIRMAN. They are coming in intelligibly?

Dr. ZIEGLER. Yes.

Mr. MCDONOUGH. That is because it went up on St. Patrick's Day.

Dr. ZIEGLER. The particular elements which we will have in multitude in those equipments will stand up under the normal radiation as we have in those orbits and the 24-hour orbit will probably be better than the one we have now.

Mr. MCDONOUGH. Of course, these will be improved satellites over the one we had on St. Patrick's Day. These will be improved over that.

Dr. ZIEGLER. Yes, they will be.

Mr. MCDONOUGH. That has operated for a year and you can anticipate at least it will operate for a year and you can hope it will operte longer, but you are not sure how long it will continue?

Dr. ZIEGLER. Not yet. We have to get more experience and we also don't know certain factors which may come in and may cause accidents like micrometeorites, showers of that kind. We don't have the full knowledge of those things, but we are confident that in general we will be able to put something up which lives for a long time.

The CHAIRMAN. You wouldn't expect this, for instance, to run out at the end of a year and all of this expense and effort, if it only lasted a year, someone may bring up the question of the worthwhileness in time of peace.

Dr. ZIEGLER. Well, even in this one year, I believe the type of communications we get with those equipments will be much less expensive than any land cable, submarine cable, or any other device we

could set up. It is very expeditiously set up as launching techniques improve.

The CHAIRMAN. Is there any way, Doctor, that you might repair a machine which might break down?

Dr. ZIEGLER. At some later time I think this could be done.

The CHAIRMAN. You have no way of providing repairs at all?

Dr. ZIEGLER. We have multiplicity of equipment.

Mr. JOHNSON. We will have two pieces in there. If one goes dead or goes bad, you can switch over to the other one.

The CHAIRMAN. You can switch it from the ground?

Mr. JOHNSON. Automatically from the ground, that is right.

The CHAIRMAN. In each one you will have duplicate machines?

Mr. JOHNSON. Mr. Chairman, I would like to point out here I don't know exactly what the number is, but I have heard it said that the annual communications bill of the Department of Defense is well over $1 billion a year, peacetime. I don't know whether this is true or not, but we would probably be able to put down a number. Communications costs are tremendous. So anything we spend here to make them better, or to reduce the costs by having our own system here would certainly be economically sound.

The CHAIRMAN. It would be partially self-supporting too, if it was used for commercial purposes.

Mr. JOHNSON. * * *

If we can free channels for military uses, then the civilian problem is eased to a very, very substantial degree all over the world.

Mr. ANFUSO. How can we get paid for doing that?

Mr. JOHNSON. Well, I don't know.

The CHAIRMAN. Instead of paying Western Union a lot of money, we would put it on the satellite.

Mr. JOHNSON. Western Union, I think, would sell more of the ground channels then, you see. I suspect the military wouldn't be buying that from Western Union. We would be getting it direct.

Mr. FULTON. Suppose Russia says this kind of a communications system is a threat to her. Now, just maybe we aren't going to be able to keep it purely military in this country nor exclusively military in the world. Then what?

Suppose she says, "We will shoot it down if you make it military" and you have to broaden it for world communications or else it doesn't work.

Mr. JOHNSON. * * *

Mr. MCDONOUGH. * * *

The CHAIRMAN. You are merely applying the principle of freedom of the seas to freedom of space.

Mr. JOHNSON. That is right.

The CHAIRMAN. It is to our interests to have freedom of the seas. You are implying the idea that it is to our benefit to have freedom of space?

Mr. JOHNSON. Yes.

The CHAIRMAN. Our connections are worldwide. Soviet connections are consolidated in one land mass. That is in Eurasia.

Mr. MCDONOUGH. Up to now there has been no question raised by the United States or Russia about the release of satellites, or even for what purpose they were released.

Mr. JOHNSON. That is right.

Mr. MCDONOUGH. As a matter of fact, do we know now that the satellites that are now operating that were released by Russia are not for communication purposes?

Mr. JOHNSON. * * *

Mr. MCDONOUGH. * * *

Mr. JOHNSON. * * *

Mr. MCDONOUGH. Do they have any location that our scientists know about in which they are capable of releasing a polar satellite in orbit?

Mr. JOHNSON. * * *

Mr. MCDONOUGH. Is Vandenberg the only location where we can take that precaution?

Mr. JOHNSON. That is right. We are going over water from Canaveral and from Vandenberg so any fallout is harmless.

Mr. MCDONOUGH. But Vandenberg is the only location in the United States we are sure of?

Mr. JOHNSON. For a polar orbit, yes.

The CHAIRMAN. Mr. Anfuso.

Mr. ANFUSO. Mr. Johnson, why is there so much stress that we classify these as military satellites? I mean you could use them militarily and perhaps that would be the sole purpose, but since they don't destroy anything, and are just used for means of communication, why do they have to be identified as military satellites?

Mr. JOHNSON. * * *

Mr. GODEL. * * *

Mr. JOHNSON. * * *

The CHAIRMAN. You would have to go back to airmail again, wouldn't you?

Mr. GODEL. The system has no utility unless it is secure.

Mr. ANFUSO. Could the Swedes have heard a thing like this?

Mr. JOHNSON. They heard something. You can turn up any antenna to a very high gain and you can hear things. I am not sure sometimes what we are hearing on our own stations, frankly, on Discoverer yet. * * *

The CHAIRMAN. I have been told you heard some gibberish which might have been attributed to an effort on the part of our machines to transmit and yet it was unintelligible. Is that correct?

Mr. JOHNSON. That is correct.

The CHAIRMAN. How long did that last after it took off?

Mr. JOHNSON. That has been intermittent at different times.

The CHAIRMAN. You are not sure in your own mind whether that really comes from Discoverer, or whether it is something picked up from, as someone said, the music of the spheres?

Mr. JOHNSON. That is right. There are a lot of noises out there you cannot identify.

The CHAIRMAN. Any further questions?

Mr. BASS. I don't see how you can make a jam-proof system in communicating between the earth and a satellite. Put it this way: If the Russians can jam a system between two points on the earth, why can't they jam it in space too?

Mr. GODEL. * * *

The CHAIRMAN. * * *

Mr. GODEL. * * *
Mr. JOHNSON. * * *
Mr. BASS. * * *
Mr. GODEL. * * *
Mr. MCDONOUGH. * * *
Mr. GODEL. * * *
Dr. ZIEGLER. * * *
The CHAIRMAN. * * *
Dr. ZIEGLER. * * *
Mr. MCDONOUGH. * * *
Dr. ZIEGLER. * * *
Mr. FULTON. * * *
Dr. ZIEGLER. * * *
Mr. JOHNSON. * * *
Dr. ZIEGLER. * * *

Mr. FULTON. Could you then say a system of communications satellites could be worked out that would make it harder for Russia to jam than a system of Earth stations; is that correct?

Dr. ZIEGLER. That is correct.

Mr. FULTON. Could you give us some figures on that sometime and what it would save? We might put you in that business too.

Mr. JOHNSON. We have enough problems.

The CHAIRMAN. Do you have any further questions?

Mr. FULTON. Seriously, I would like to have that, though, a comparison of what advantage there might be in this kind of a system for broadcasts of a general nature as opposed to current systems and as well the degree of jamming that is possible as against a military system of narrow bands?

Mr. GODEL. * * *

Mr. FULTON. I would like to determine what the difference is between the Voice of America and this military type of jamming.

Dr. ZIEGLER. * * *
Mr. FULTON. * * *
Dr. ZIEGLER. * * *
The CHAIRMAN. * * *
Mr. JOHNSON. * * *
The CHAIRMAN. * * *
Mr. JOHNSON. * * *
The CHAIRMAN. * * *
Mr. JOHNSON. * * *
Mr. FULTON. * * *
Mr. JOHNSON. * * *

Mr. MCDONOUGH. I have one question. Is the orbit of the polar satellite smaller than the others or is that just a relative drawing?

Mr. PRICE. It is smaller.

Mr. JOHNSON. It is 5,000 miles as against 19,000 miles.

Mr. MCDONOUGH. Is it possible that a polar orbit necessarily must travel slower than an equatorial orbit?

Dr. ZIEGLER. I think the implication here is this, that you can in an equatorial orbit in the so-called 24-hour or synchronized position, you can make a satellite stay fixed with regard to a point, but you cannot do this on a polar orbit.

If you could do this, we would launch over the south pole and over the north pole, but there is no way, due to the mechanical laws, to get one staying fixed. It would always prescribe a figure 8 on the surface of the earth and for that reason there is no sense going to the 24-hour orbit and if a satellite moves, all right, it may as well use its better payload at a lower orbit and for that reason the lower orbit is used and it is optimized with regard to payload and coverage to approximately 6,000 miles out.

Mr. FULTON. * * *

Mr. JOHNSON. * * *

The CHAIRMAN. * * *

Mr. JOHNSON. * * *

Mr. FULTON. * * *

Mr. JOHNSON. * * *

Mr. GODEL. * * *

The CHAIRMAN. Are there any further questions?

If not, it is after noon and we will adjourn until tomorrow morning at 10:30.

I want to thank you gentlemen very much for being here.

(Whereupon, at 12:20 p.m., the committee adjourned, to reconvene at 10:30 a.m., Wednesday, March 4, 1959.)

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., Wednesday, March 4, 1959.

The committee met at 10:45 a.m., in the caucus room, Old House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The meeting of the committee will please come to order.

Before we get underway, Mr. Ducander has a matter he wants to take up before the committee. Mr. Ducander, I will ask that you read the letter. I understand also that the individual members have been contacted, but I think it would be wise to have the letter read.

Mr. DUCANDER. The chairman has received the following letter and I understand a similar letter is going to each of the members concerning an invitation for a get-together on the 16th of March.

The letter reads as follows:

MY DEAR MR. CHAIRMAN: You are cordially invited to attend a stag briefing by the Chief of Naval Operations and the Commandant of the Marine Corps describing concepts of employment of naval forces in the modern age. The briefing will be conducted on board the U.S.S. *Sequoia* on Monday, March 16, 1959, at 6 p.m. A buffet supper will be served after the briefing. It is expected that the U.S.S. *Sequoia* will return to the Naval Air Station, Anacostia, and moor at 9 p.m. Automobile transportation will be provided from the House Office Building to the *Sequoia* berth at Anacostia and return, departing New Jersey Avenue and C Street at 5:30 p.m.

It would be appreciated if you would advise your assigned Navy liaison officer whether or not you plan to attend.

Sincerely yours,

THOMAS GATES,
Secretary of the Navy.

The CHAIRMAN. We have had a lot of testimony here in the committee, and this committee, I think, has been most zealous. I want to again commend everybody on the committee for being so faithful in attendance. This promises one opportunity that the committee will have to transact business and under a little different environment. As you know, we have no home. So I suppose it is just as proper to meet on the water as it is on the land. We can get a good deal out of this.

I myself plan to attend and I hope that all members of the committee plan to attend. I would like to see how many members here think they could make that Monday evening.

(Show of hands.)

The CHAIRMAN. That looks like all of them present. How many are present here?

Mr. MILLER. Governor Brown, of California, is going to be in town that day. A reception is being tendered to him at the Statler Hotel. You realize the position Mr. Sisk and I are in with respect to that.

The CHAIRMAN. Everybody here then will be able to make that. I suggest to Mr. Ducander that the committee staff contact the absent members so as to see who else will make it.

This morning we have five witnesses planned on the subject of international telecommunications and communications satellites.

We are going to change the order of the witnesses because we are short an extension cord to show the pictures. Therefore, with the consent of everybody, we will shuffle the witnesses around just a little bit—not with the idea of placing any priority on any witness, but with the idea of making it possible so that these pictures can be used and we will be ready for it.

I am going to suggest this. Since we have five witnesses and every one of them has come from distant points for this committee hearing, that the committee permit all to proceed with their prepared statements and then we will take up each prepared statement. After all of the prepared statements are in, then we can question the different witnesses who have been here.

In that way nobody will be denied an opportunity today to be present before this committee.

If there is no objection to that procedure, I call Dr. John R. Pierce, director of research, communications principles, Bell Telephone Laboratories.

Mr. Haley, we called your name just a little earlier, but you were delayed. We would be happy to have you sit here. I might say this: One of our members and one of our hard-working members, too, has asked for the privilege of presenting you after we call on Dr. Pierce. When we get to your name, I am going to ask Congressman Anfuso to formally introduce you to the committee.

Mr. FULTON. That doesn't prevent us from cross-examining him, does it?

The CHAIRMAN. I think you can proceed in regular order after the introduction has been made.

Doctor, do you have a prepared statement?

STATEMENT OF DR. JOHN R. PIERCE, DIRECTOR OF RESEARCH, COMMUNICATIONS PRINCIPLES, BELL TELEPHONE LABORATORIES

Dr. PIERCE. I have some informal remarks I have prepared.

The CHAIRMAN. All right, if you will proceed with your remarks, we will be pleased to have them. I want to say this to the press. I am very sorry, but under the rules of the House we just can't allow pictures to be made here. We will get in trouble. I might say if Mr. Haley would like to step out in the corridor for a moment, you can get all the pictures you want made there and he can come back in, in time to testify.

You missed Mr. Haley. He came in late.

Dr. PIERCE. The Bell Laboratories is an organization which designs essentially all the telephone equipment used in the Bell System. This includes not only telephone instruments, but also switching systems and long distance communications systems.

The research department is one of several departments of the Bell Telephone Laboratories. The research department is divided into three parts, and I am in charge of one of these. My title is, director of research, communications principles.

I do not have directly to do with the design of present-day communication equipment, but rather with looking into and working toward the future.

I received my B.S., M.S., and Ph. D. degrees in electrical engineering from the California Institute of Technology in 1933, 1934, and 1936. I have been with the Bell Laboratories ever since. My principal work has been in the field of microwave tubes and communications. I have published many technical papers, two technical books, and two popular books on technical subjects. I am a member of the National Academy of Sciences, a fellow of the Institute of Radio Engineers and of the American Physical Society, and a member of the Acoustical Society of America, the American Rocket Society, and the British Interplanetary Society.

The Bell Laboratories is naturally interested in all new sorts of communication. As early as 1954 we looked into the matter of satellite communication seriously. In 1955 I published a paper, "Orbital Radio Relays," in the journal Jet Propulsion.

This paper considered the matter of satellites for long distance communication. At that time it appeared—and to me it still looks as if—the natural field for use as such satellite relays was in transoceanic communication, a field in which one has some difficulties with other means of communication.

At that time I made calculations concerning the use of passive reflecting satellites, that is, large spherical objects, for instance, that could be used to reflect microwaves beyond the horizon and over to another continent. I also considered corner reflectors, another type of reflecting device, and I considered the use of large plane mirrors rather than spherical reflectors, because mirrors can reflect a larger signal back.

I also considered the use of active satellites with directive antennas on them. I considered the use of satellites in orbits a few thousand miles high and orbits 22,000 miles high where the satellite goes around in 24 hours and stays always over one portion of the Equator.

At that time we wondered what sort of work could be done toward this. Our competence is not in rocket vehicles, and there weren't any artificial satellites at that time. It seemed to us, then, that the best thing to do was to keep this matter in mind and to pursue advances in the microwave art which would make satellite communication more attractive.

Indeed, just in those 4 years, between 1955 and now, there have been a number of very important and pertinent advances in the microwave art.

We now have larger and better microwave antennas than we had then. You can now buy, just by taking your money to some commercial company, 10-kilowatt microwave klystrons, which didn't exist at that time. We now have broad band transistors, which could be used in an active repeater if one wanted to put a radio receiver and transmitter up in an active satellite, and we have much higher frequency transistors. We have much radio astronomical data that tells what sort of noise comes from the heavens which might interfere with a satellite communication system.

Particularly, we have a new sort of microwave amplifier called a maser, which in amplifying signals introduces only about a hundredth of the noise that the amplifiers of 5 years ago introduced. That means you need only about a hundredth of the transmitter power today that you would have needed 5 years ago.

I think that this is an example of the steady change that we may expect in science and technology. The matter of satellite communications now looks quite different from what it did 5 years ago, and we may expect it to look quite different 5 years from now from what it does now.

Of course, above all we now have satellites going around the earth, and a demonstrated capability of putting up, at least into low orbits, substantial satellites. We have had in the Atlas satellite a demonstration that we can put communication equipment up.

This raises many questions as to what might be or should be done with communication satellites. There are still many difficult problems and much technical knowledge that is missing.

Above all, it is clear that satellites can provide only a part of the communications that the world needs in any foreseeable future. They aren't going to replace the PBX in this office building, and they aren't going to replace telephone exchanges in any foreseeable future.

Satellites will supplement all the other different sorts of communication, and it is awfully important that they provide some communication that is reliable and useful and attractive in comparison with other communication. Of course, this is what science gives one in the long run. The submarine telephone cable not only gives a better circuit than shortwave radio, but it is cheaper.

Now there are some general problems concerning satellites that it is very difficult to answer at present. One is that satellites are completely in the public domain in a way that nothing ever before has been. They are up in the sky where everyone can see them, and unfortunately anyone who wishes to could shoot radio signals at them.

There is a question of how one can restrict and control the uses of satellites that are put up in the sky. If one just puts up a satellite and allows a lot of people access to it, when they all get in a hurry

you will end by having no communication, because the messages will all jam one another. There is also the possibility, of course, that somebody would deliberately jam the satellites. So a satellite communication system will be good only if it is kept in some sort of control.

There is also the question of interconnection with other communications. Satellites will certainly be used in any immediate and initial phases to get between certain points, and from there the communication path they provide will have to be integrated with other communication systems, so that somebody in a hurry, whose particular need for this transoceanic communication was not necessarily foreseen, can get his message to where it takes off on the satellite system.

Finally, there is, of course, the question of cost. I don't mean the cost of planning a particular rocket launching with a certain amount of equipment. I mean the real cost of establishing and maintaining continuous reliable and uniform service; service that will not only be a demonstration of communication but will be communication that somebody can use and rely on in an emergency.

I just raise these problems because I think they are very important. Right now we are hardly in a good position to deal with such problems or to prescribe how one might meet such difficulties. They are too new and we are at too early a stage.

So having raised these broad issues, I won't settle them, at least not satisfactorily. But I want to turn to some narrower technical issues about which I can perhaps talk some sense.

One thing I would like to say, of course, is that there are various uses for satellites that require different sorts of reliability and that are nearer or farther away. There may be military uses to provide vital communication with inaccessible polar land areas where there is no other communication that one could rely on. In that case it could be well worth the expense and the effort to try to get satellite communication immediately, regardless of how reliable it will prove, or how costly it may be.

In other applications, satellites are an alternative to other methods of communication. In communicating over inhabited land, over a civilized country such as the United States, it seems obvious that they are going to be very expensive and inflexible compared with cable and microwave radio networks. On land, cables and microwaves give one the option of going from any point to any other point and of setting up circuits for particular purposes. On land, cable and microwaves are far cheaper than anything else we have—far cheaper, for instance, than transoceanic cables.

In the transoceanic communication, however, the satellites have much more promise. At the moment we don't have any broad band television-type facilities for transoceanic communication.

While submarine cables can in principle be made broad band, and while there are other possible alternatives, satellites look attractive for transoceanic communication, providing some of the technical matters turn out the way that one expects and hopes that they will.

There are several possibilities in such transoceanic communication. One is one that I have looked into at length and have published a paper on, together with Mr. Kompfner, in the record of the national symposium on extended range and space communications, which was held in Washington October 6–7, 1958, under the auspices of the pro-

fessional groups on antennas and propagation and communication systems of the Institute of Radio Engineers. The paper will also appear in an early issue of the "Proceedings of the Institute of Radio Engineers." This paper gives an example of what you can do technically with spherical passive reflectors.

Such a passive system requires rather large ground installations to provide a television channel across the ocean. It would require 100 kilowatts of 2,000 megacycles microwave power. It would require 150-foot antennas. But these things, or parts of them, are being done for other reasons. This appears to be more or less within the art.

Such a system would be expensive, but the equipment is all on the ground where one can install and repair and change it. Aloft would be merely a 100-foot sphere or balloon in orbit.

NASA has announced that for their own purposes they contemplate putting up such a balloon. It would be made of Mylar coated with aluminum, I understand.

One sphere in a polar orbit 3,000 miles high would be visible from both Newfoundland and the north of Scotland, which will be about the shortest path you can get in spanning the Atlantic, about 20 percent of the time. So even one sphere would give you communication for half-hour or longer every 3 hours.

If you put up 24 such spheres in random orbits (you don't have to guide them very precisely), just by chance you would have one visible from both ends 99 percent of the time.

This proposal has several things to recommend it. There is no electrical equipment aloft, and so there is nothing to wear out. There is no electrical equipment aloft that anyone could jam. And once you have the reflector up there, you can use it to reflect microwaves of many different frequencies between many different locations, so that you can add to the communication or you can change the sort of signal you are sending without altering what is up in orbit. It is very flexible from that point of view.

It has the disadvantage in that it may, in the long run, be less economical than putting active repeaters up. When you put an active repeater up you have the cost of replacing the repeater from time to time. However, you need less power on the ground.

There is another question—that is, the durability of such satellites. We have taken some of the material such satellites might be made of and have measured the amount of heat it reflects and absorbs to try to see how hot the thing would get. We have measured the effect of ultraviolet light on it. This by no means settles the problem. One doesn't really know about a thing unless he has done it. We are looking forward with great interest to what experience the National Aeronautics and Space Administration will have with such a satellite.

I will turn for a moment to active repeaters. No doubt other people will say more about these. Here, too, there are a number of unsettled questions.

After many, many years of development on the submarine cable, we have put amplifiers under the ocean that we expect to last at least 20 years. But this took many, many years and many tests of all the components, and a great deal of rejection of components.

Here the question is of putting up something that will have no small requirements on its capabilities, and something that we will ask

to last not for a few weeks or a few months, but something new which we will ask to last for years.

It will have to have batteries for power sources, such as solar batteries; it will have to have storage batteries. There is the problem of heat dissipation, because you can't blow on things in a vacuum to cool them. You have to bolt everything to the frame so that it is cooled by conduction of heat away by the frame, and by radiation.

There is a real question of what we can say in advance, right at this point, about how to make a satellite that has to last years.

An active repeater, of course, has only the capabilities you build into it. It will handle the sort of signal and the amount of signal you plan when you send it up, unlike a passive reflector which will reflect any signal you send up.

On the other hand, the active repeater, the radio transmitter up in the sky, sends back a stronger signal, and it will be capable of operating from a weaker signal from the ground, so you will have cheaper ground equipment.

These problems are exaggerated. If you want to put an active satellite up in the 22,000 mile, 24-hour orbit, so that it will stand over one part of the Earth's surface, over one part of the Equator. In this case you have added questions of station keeping. You have to get the satellite up pretty accurately, and then you have to have some corrective mechanism to keep it at just the right place. Otherwise it might drift around to the other side of the Earth and be there for 6 months.

For the best sort of 24-hour satellite, you have to have an oriented satellite. You have to have some little jet or other mechanism up there that will be under continual control all the years of its life with perfect reliability, something which will point the antennas at the right place.

What life you can expect out of those things right now, I don't know. Others may be able to testify better. But I feel that the time when we will be able to say the things about these satellite proposals that we say about other sorts of communications systems which we install from day to day is some time in the future.

Now I might say a couple of words about the Bell Laboratories' program. Primarily we are seeking more knowledge, so that we can make sure comparisons and judgments concerning satellite communication.

I am sure satellite communication has a future, but we don't feel we are in position to pinpoint in great detail what the future will be very far ahead. We can say what some of the near things are, I think.

We have been working on masers. These are these very low-noise amplifiers. We have one right out now hitched to antenna measuring the sky temperature just to be sure that the radio astronomical data we have on the noise from the haveans is accurate.

The maser will give a low noise only if the antenna sees or looks at only the sky and not at things out to the side and not at things behind it. This requires a special sort of antenna because most antennas send a little bit of energy out in all directions, and receive a little bit of energy in all directions. We have designed a model of, and are going ahead with the construction of, an experimental antenna

of a special sort which we believe will be very valuable in satellite communication. It is what is called a horn reflector antenna. Its characteristic is that it sends the radio energy out, or receives it, from essentially only one direction, and less than a millionth as much from any other direction.

We have been working investigating special modulation systems. Single sideband is good in telephony and in shortwave radio, and the FM is so good in microwave radio, and the pulse code modulation, which I won't try to explain, has other advantages.

These are so good for other things, but may not be appropriate for satellite communication. We have mathematicians and engineers working on these matters.

We are looking into the question of whether solar batteries can be improved and made more efficient.

We have already been working on high-frequency transistors and we are augmenting that effort to see to what degree transistors can be used, rather than vacuum tubes, at high frequencies.

We are doing work on longer life microwave tubes. In the past we have had tubes for lower telephone frequencies that will last 20 or more years, but they had to last that long because they are put on the bottom of the ocean. Our other tubes have been put in accessible places and we have not put such demands on them, although many of them last for many years.

Here it is of the utmost importance that somebody work on tubes which, if you fire them up from the Earth, can be expected, not on the average—that doesn't do you any good—but with a high degree of certainty, to last several years.

We are doing orbital computations to find the effect of the light pressure and other things on orbits of various sorts of satellites.

Finally, we are having installed a 60-foot microwave antenna and a powerful transmitter. With this, we intend to observe the signals from any microwave satellites that may be put up, in order that we may understand propagation. If there are any satellites large enough put up, such as the NASA balloon, which can reflect an appreciable amount of microwave energy, we will be able to make propagation measurements by shooting energy up and having it come back toward us.

In this effort we have about 24 professional people, plus technical aids who have some substantial responsibility for pertinent work. There are perhaps six to eight people who are working essentially full time on satellite communications problems.

(There follows a supplementary statement by Dr. Pierce for the record:)

NEW POSSIBILITIES IN LONG RANGE COMMUNICATION

By J. R. Pierce, February 4, 1959

I am going to talk primarily about some of our pioneering work in the Bell Laboratories which may be important in helping the Bell System to meet the world's needs for broadband transoceanic radio communication in the future.

Such work is bound to seem exotic in its inception, just as radio itself seemed exotic in an earlier day. Sometimes a form of radio communication never adapts itself to Bell System needs. This was the case with radio broadcasting. Early work did teach the Bell System a good deal technically and helped to found an industry to which we provide many program channels; but the Bell System soon got out of the radio broadcasting business.

In a number of cases, however, pioneering work has enabled the Bell System to provide new and important forms of radio transmission.

In 1915, the A.T. & T. and Western Electric made use of newly developed power vacuum tubes in demonstrating radio communication between Arlington, Va., and both Hawaii and Paris. This showed a potentiality for transoceanic communication which could not be overlooked. It led directly to experimental work in transatlantic telephony as early as 1923 and to the inauguration of commercial transatlantic telephone service in 1927.

This early long-wave experience showed the importance of good scientific and engineering work. Accurate field strength measurements were made. A form of modulation was adopted, in this case the first use on radio of single sideband, which was suited to the nature of the medium and the needs of the system. This pattern of careful measurement and thoughtful design has shown its value in all subsequent Bell System radio work.

For instance, shortwave radio, which was put into commercial service in 1928, proved to be a tricky sort of communication, and it is only through the sound and fundamental work of the Bell Laboratories that it can be used as effectively as it is.

Shortwave propagation shows both long-term variations of signal strength and rapid fading. Careful measurements showed the multipath nature of the fading and showed that the vertical and horizontal angles of arrival of various signal components vary with time.

Such extensive and accurate measurements made it clear that it was desirable to change the frequency of operation to suit the condition of the ionosphere. The early antennas were elaborate arrays which could operate over a very narrow range of frequencies only. The invention at the Bell Laboratories of the simple rhombic antenna made it possible for transmitters and receivers to operate effectively over a wide range of frequencies. The MUSA system, an array of rhombic antennas interconnected with phase changing networks, made it possible for the receiver to follow the changes in angle of arrival which had been observed in propagation measurements.

Work on noise in the shortwave bands by K. G. Jansky from 1929 through 1931 led to the detection of extra-terrestrial radio noise, and ultimately to the foundation of radio astronomy.

Besides shortwave work, higher frequencies were explored, and much fundamental knowledge was gained, which was used in establishing a number of over-water systems. It was, however, in the case of microwaves that the next large-scale Bell System application of radio was found.

G. C. Southworth started his work on microwaves as early as 1932, long before any use for them could be assured. The work was taken up by Harold Friis and his cohorts in 1938.

Here again we had the pattern of early scientific and exploratory work leading to extensive measurements and studies and the development of a sound technical art. This led to the New York-Boston experimental system in 1947 and provided the background for the development of the transcontinental TD–2 system which went into operation in 1951. Before that, the knowledge we had gained proved invaluable in our microwave radar work during World War II and also to the MIT Radiation Laboratory.

As in previous cases, there was a lot to learn about microwaves. Measurements showed that a microwave path which cleared intervening obstacles by a certain minimum amount (first fresnel zone clearance) was good. Angle of arrival measurements showed the existence of multipath fading. They showed that highly directive antennas are best. This set a pattern in Bell System microwave systems in which very good highly directive antennas are used to minimize interference between systems and between links of the same system. In turn, use of these high-gain antennas has made it possible for systems to operate on very low powers. Finally, all of this careful work showed that microwaves could provide very reliable service indeed.

Radio pioneering can involve the use of new frequencies. It can also involve sending radio waves in new directions. As early as 1934 A. M. Skellett and W. M. Goodall in their studies of the ionosphere looked for reflections from ionized meteor trails at frequencies from 2 to 6 megacycles. These frequencies were too low to give a strong signal, but they thought they detected the effect statistically.

In 1951, workers outside the laboratories proposed the use of beyond-the-horizon scatter from turbulence in the ionosphere in a long-range radio system. A 776-mile, 50-megacycle circuit was established between Cedar Rapids, Iowa,

and Sterling, Va., in January 1951. By February, these signals were monitored by Bell Laboratories. More elaborate antennas were set up in the period between 1951 and 1954 and teletype messages were received at Holmdel.

During this work, very high signal strengths for very short times indicated strong reflections from meteor trails, a verification of Skellett's and Goodall's early ideas. This sort of transmission has been used in a specialized type of military communication, as in the Canadian "Janet" system.

In all, however, this exploration of both ionosphere scatter and meteor trail scatter showed us that these sorts of radio propagation are too narrow band and too erratic to be of interest in providing long distance telephone circuits.

Tropospheric scattering of radio signals from turbulence in the atmosphere a few miles above the Earth has proved to be more important. Here the pioneer work was done by Kenneth Bullington of the Bell Laboratories. In 1950–51 Bullington made tests over paths from 200 to 300 miles long and also collected extensive data from other sources. He pointed out the existence and possibilities of this mode of transmission in a letter to the proceedings of the Institute of Radio Engineers in 1950, and this was followed by a paper in 1953.

In 1955, a 60-foot scanning antenna was set up at Holmdel and propagation studies were conducted by means of an almost automatic transmitter which was set up at a farm at Pharsalia, N.Y., 171 miles away, and turned on and off by the farmer's wife. Propagation studies carried out from 1955 through 1958 gave us extensive data at both 460 and 4,100 megacycles on the effect of the antenna size and the dependence of signal strength, fading and rate of fading of wavelength, and on the angle of arrival. This data was compared with the predictions of Harald Friis' theory that the scattering is caused by a large number of randomly placed but nearly horizontal discontinuities in dielectric constant a few miles from the Earth's surface. Theoretical predictions and the measurements fit very well in most respects and are used by many people as the basis for the design of scatter circuits.

In order to be very sure of our knowledge of the nature of scatter propagation, which we believe to be the best in the world, we are now conducting a radar type of experiment in which the antennas are aimed vertically in an effort to directly detect and locate the layers responsible for the scattering.

Scatter circuits designed by the Bell Laboratories and installed by Western Electric were in operation in the Arctic in the "Polevault" system in early 1955. The DEW line, providing communication between the various radar stations, was completed in 1957, and the "White Alice" system, providing extensive voice communication in Alaska, in 1958. Further, in 1957 a broadband scatter circuit was put into operation between Key West, Fla., and Havana, Cuba, which provides 36 telephone channels and could provide more. It is also frequently used for television between the United States and Cuba.

Although tropospheric scatter propagation does enable us to span distances beyond the line of sight with broadband circuits, it is extremely expensive compared with a much better microwave radio relay channel which can be used overland. Indeed, even in one link a sort of selective fading which is inherent in the nature of scatter communication makes channels of television bandwidth marginal in quality.

Some people have proposed to provide transoceanic television and other broadband communication by means of long scatter circuits extending from the mainland of America across various gaps to Greenland, around or over Greenland, from island to island to Scotland, and thence to Europe. Our careful studies of scatter propagation indicate that such a circuit would necessarily be extremely expensive because of the large antennas and high power transmitters which are necessary, and especially because these would have to be located in out-of-the-way places which are difficult to supply. Further, because of the selective fading we have observed over a television bandwidth in one channel, we believe that a broadband multilink scatter system would give a very poor broadband circuit, although it could be used effectively for a substantial number of telephone channels.

What should we explore now in seeking new sorts of radio communication for the Bell System? As early as 1954 we looked into the matter of artificial earth satellites as relays in providing transoceanic communication, and in 1955 I published a paper on the subject. The figures indicated that this had possibilities if only one were able to put satellites up. At that time this did not seem imminent, and we kept our minds open but did no experimental work. The launching of the first sputnik in October 1957 changed this picture, and we started to look into the possibilities of satellite communication much more seriously.

Here, as in such previous fields as longwave, shortwave, microwaves, and ionospheric and tropospheric scatter, there are many uncertainties which only study and experimental work can resolve. Thus, it is impossible to say at the moment either what may be the ultimate usefulness of satellite communication or what sort of system might initially be most useful or successful. Some proposals suggest several satellites placed very accurately in orbit 22,400 miles above the Equator, so that they will go around with the earth in step with the earth's rotation and hang always in the same position in the sky. Certainly reliable transmitters and receivers with accurately pointed directive antennas on such satellites could provide valuable communication, but both the problems of the accurate rocketry necessary to launch and orient such satellites and the problems of equipment life on the satellites make such a system seem very far away. Another possibility is to put satellites in orbits a few thousands miles above the earth. These satellites might carry transmitters and receivers and so be active satellite repeaters. However, in the case of such nearby satellites, it would suffice to put up a large spherical reflector perhaps 100 feet in diameter, and indeed the National Aeronautics and Space Administration is contemplating the launching in 1959 of just such a sphere made of aluminized mylar.

As an exercise to find what sort of possibilities even simple satellite communications systems might have and what the problems concerned with them are, we have studied in some detail a system using a number of passive satellites for transoceanic communication.

Since the greatest need for communication seems to be between the United States and Western Europe, we picked as one terminal a point in Newfoundland and as another an island off the coast of Scotland, as these locations are both accessible and close together. (Table A.) The first figure shows this route in a polar projection. Also shown are certain closed contours labeled 500 miles, 1,000 miles, 1,500 miles, 2,000 miles, 2,500 miles, and 3,000 miles. For instance, a contour will be simultaneously visible from both terminals. The disposition of these contours on the map has shown us that polar orbits which pass repeatedly over the North and South Poles would be the most effective for providing communication between such terminals. The heavy lines show how satellites in polar orbits would pass over the face of the earth as the earth rotates with respect to the orbit.

We can easily calculate for various heights of orbit, the orbital period, the shortest and longest times of mutual visibility, the average visibility, and the extreme distances to the satellite. These are displayed in table B. For instance, a satellite at a height of 3,000 miles would be visible from both terminals each revolution. The least period of visibility would be 31 minutes, the longest period of visibility would be 55 minutes, and the average visibility would be 22 percent of the time. Thus, one might get quite long stretches of broadband communication by means of a system using only one satellite.

These calculations are pertinent only if we receive from and transmit to the satellite right down to the horizon. Is this practical? In a satellite communication system we need to use the least noisy receiver we can possible make, and fortunately the maser has provided us with a microwave receiver which adds practically no noise to the received signal.

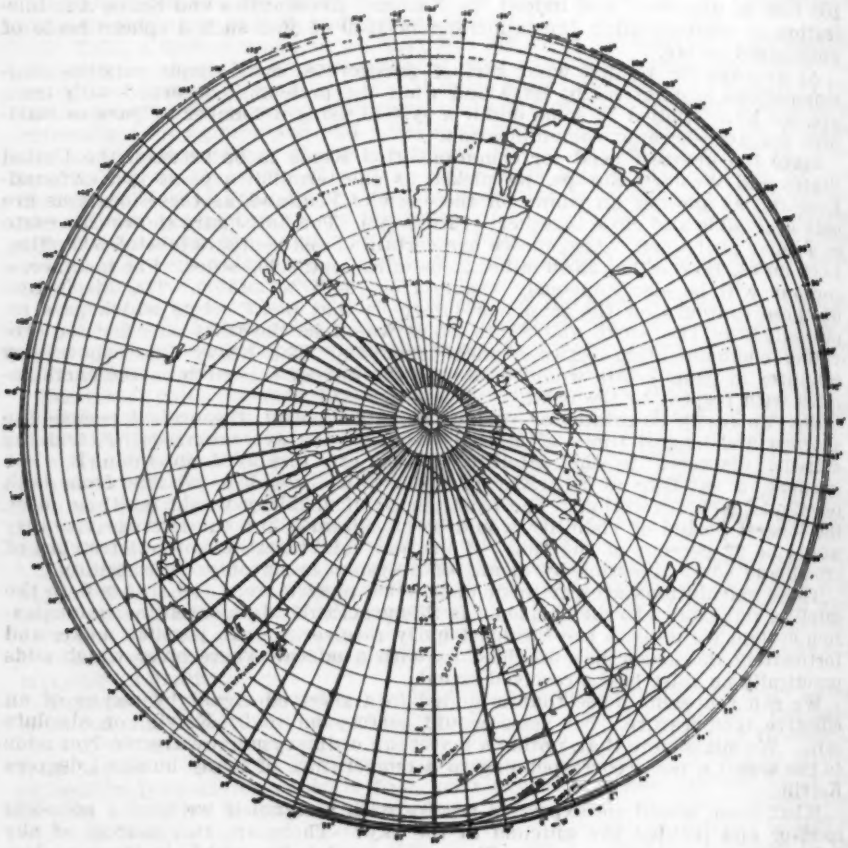
We can represent noise that is added to a received signal by means of an effective temperature. No noise would correspond to 0° Kelvin, or absolute zero. We might note that, unlike a maser, an ordinary microwave receiver adds to the signal a noise corresponding to a temperature of many hundred degrees Kelvin.

What noise would we expect to receive with a signal if we used a noiseless receiver and pointed the antenna at the sky? There are two sources of sky noise. One is the cosmic noise discovered by Jansky, which is large at low frequencies but small at high frequencies, as shown by the minimum and maximum lines at the left of the chart. The other noise is due to the temperature of the atmosphere, for the atmosphere of the earth is hot compared with absolute zero, and it radiates electromagnetic waves just as hot iron radiates light and heat. If the atmosphere were perfectly transparent we wouldn't receive any radiation from it, but oxygen in the atmosphere causes the atmosphere to be not quite transparent at very high frequency microwaves. If we look out toward the horizon we see a lot of atmosphere and pick up more noise from it; if we look straight up we see less atmosphere and less noise. The curves on the chart (fig. 3) show how the noise temperature changes with frequency and with angle

TABLE A.—*Number of randomly spaced satellites required to give service interrupted no more than 100 percent, as a function of minimum elevation for orbits at 3,000-mile height*

Minimum elevation angle (degrees)	Number of satellites for indicated percentage of service interruption		
	10	5	1
0	9	12	19
3.25	11	14	21
7.25	12	15	24
12.60	17	22	33

Assumption: Terminals in Newfoundland and Hebrides polar orbits.



Note: For the sake of comparison with Fig. 2, polar orbits at the 2000-mile height have been darkened.

Fig. 1 - Regions of Mutual Visibility of Satellites in Circular Orbits at Various Heights

TABLE B

	Height above surface of earth (miles)					
	500	1,000	1,500	2,000	2,500	3,000
Time of 1 revolution (minutes)	100.4	118.0	136.6	155.0	175.2	195.2
Shortest visibility (minutes)	0	0	8.0	12.5	23.8	31.4
Longest visibility (minutes)	14.7	20.0	29.6	36.6	46.2	55.4
Average visibility (percent)	3.5	6.9	12.9	17.7	19.6	22.0
Longest distance from A or B to satellite (miles)	2,050.0	2,980.0	3,755.0	4,450.0	5,099.0	5,718.0
Shortest distance from A or B to satellite (miles)	1,180.0	1,540.0	2,100.0	2,670.0	2,820.0	3,300.0

Assumptions:
Terminals in Newfoundland and Hebrides.
Polar orbits.
Refraction effects ignored.
Visibility from horizon to horizon.

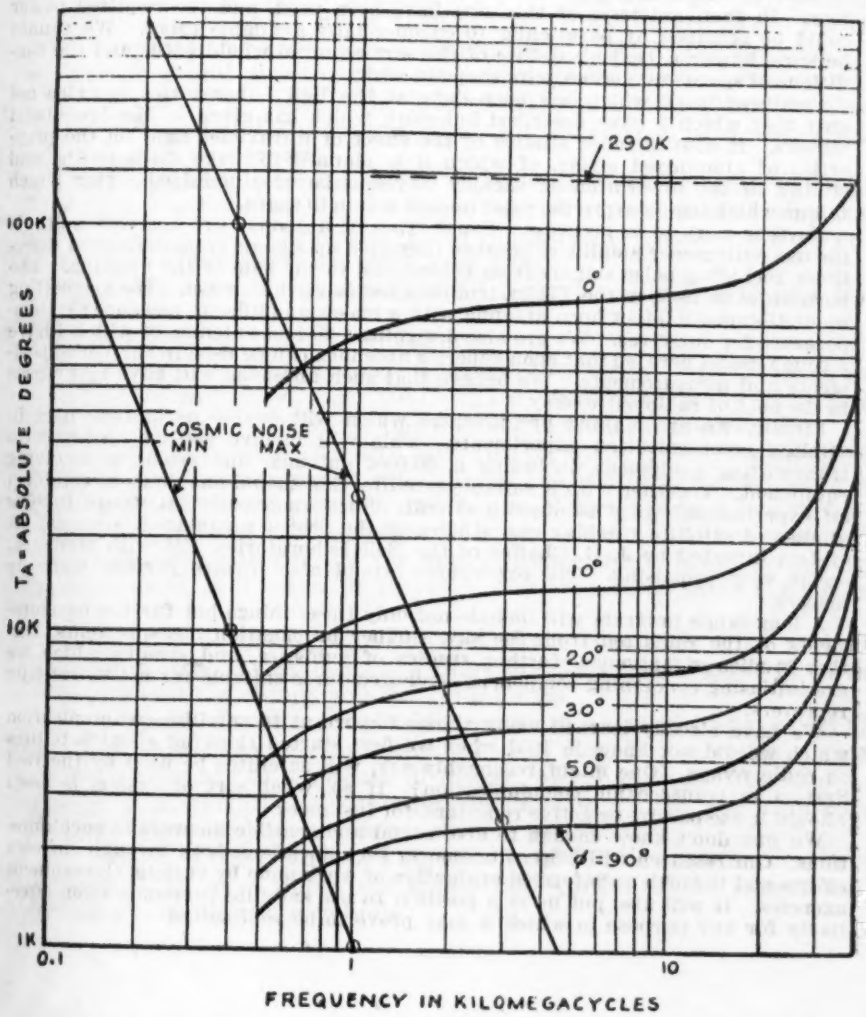


Fig. 3 - Temperature due to Oxygen Absorption Seen by an Ideal Antenna as a Function of Elevation Angle φ and Frequency

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of elevation above the horizon. These curves make us feel that we can realize the advantages of our master receiver if we try to receive signals from the satellite only when it is 7° or more above the horizon.

Suppose we consider satellites 3,000 miles high and use them only when they are at least 7° above the horizon. As we put more and more satellites up the fraction of the time that at least one satellite will be visible from both terminals increases. For 24 satellites, a satellite would be available 99 percent of the time. Moreover, interruptions would occur at predictable times and hence we would have a very reliable circuit.

We have computed the transmitter powers and antenna sizes that would be necessary to give a television channel with a 40-decibel signal-to-noise ratio over various distances. For instance, for the system I described, with a 100-foot spherical reflector, we would require antennas with diameters of 150 feet, and a transmitter power of 100 kilowatts at a frequency of 2,000 megacycles. No such transmitters and antennas are in operation, but the individual requirements of antennas, noise temperature, and power output could be met by means of devices which have at least been demonstrated and measured in the laboratory. In fact, antennas of this size have been used, and the required power could be obtained by paralleling 10 commercially available tubes. We cannot be sure, however, that a satellite of the sort required would withstand the conditions of space and maintain its shape in orbit.

Pertinent work which has been done at the Bell Laboratories includes not only that which I have described but work which has given us the broadband masers. It also includes studies of the effect of ultraviolet light on the properties of aluminized mylar, of which it is planned to make the satellite, and studies of the absorption at various wavelengths of aluminized mylar which tell us which temperature the satellite will attain in space.

Further work is in progress. Usual types of antennas are not very suitable for use with maser amplifiers because they pick up signals from undesired directions, including noise signals from behind and to the side of the antenna. The horn antenna used in the TH system does not have this defect. We are setting up at Holmdel a 5-foot horn antenna with a maser amplifier to measure sky temperature for ourselves. We are also designing a 20-foot antenna, of which I have a rough model here, so that such superior antennas can be used in further experiments and measurements. We believe that such antennas will have many uses in the field of radio astronomy.

Finally, we are making preparations which will enable us to take part in satellite communication experiments. This will involve setting up powerful transmitting equipment, including a 60-foot antenna, and sensitive receiving equipment. Together with a suitable satellite, this should enable us to establish an experimental voice bandwidth circuit. Such an experiment would involve studies of satellite tracking and studies of the proper modulation systems. A system invented by J. G. Chaffee of the Bell Laboratories, FM with feedback, seems very promising. The experiment would also involve further work on masers.

A long-range program will include not only these things but further measurements of the radiation from the sky, further propagation measurements, further studies of antennas, further studies of guidance, and studies which we are initiating concerning components and structures suitable for active satellite repeaters.

We have already learned many things important to satellite communication which we did not know in 1954 when we first started thinking about satellites as radio relays. One might reasonably ask, will satellites be used by the Bell System in transoceanic communication? If so, what sort of system is best? Should it use passive or active repeaters, for instance?

We just don't know enough to give sound and sensible answers to such questions. Our research will help us to answer such questions, both through our own efforts and through an informed evaluation of work done by various Government agencies. It will also put us in a position to use satellite communication effectively for any purpose to which it may prove to be well suited.

The CHAIRMAN. We certainly thank you for the statement. I think everybody on the committee has a lot of questions to ask you, Dr. Pierce. We are reserving those questions and everybody make a note, if they will, of the questions they have.

At this time can we call on Mr. R. P. Haviland of the General Electric Co., director of the American Astronautical Society. Is that machine in operation now?

STATEMENT OF R. P. HAVILAND, GENERAL ELECTRIC CO., DIRECTOR, AMERICAN ASTRONAUTICAL SOCIETY

Mr. HAVILAND. By way of introduction, Mr. Chairman, I received my B.S. degree in electrical engineering in 1939 from the Missouri School of Mines. After graduation I worked as a geophysicist in Texas and Louisiana. From 1942 to 1947, I was on active duty with the U.S. Navy, and am now a commander, U.S. Naval Reserve. I am a Fellow and director of the American Astronautical Society.

I first started to work in the field of astronautics in 1945. At that time I initiated and was project officer for the Bureau of Aeronautics' satellite study program.

The CHAIRMAN. Just a moment, if you will, Mr. Haviland. Would it be better as we alternate witnesses for the witness to sit facing the entire committee? Otherwise, these Republicans here—you have got your back to them and they can't hear you.

Mr. HAVILAND. If you can hear all right I would like to face the screen.

The CHAIRMAN. That is all right.

Mr. HAVILAND. Thank you. This satellite work at the Bureau of Aeronautics continued until 1947. As it was approaching its end, I left active duty in the Navy and joined the General Electric Co.

Working on missiles, rockets, and also on space travel, for the past 3 years I have been engineer, satellites, of the missile and space vehicle department of the General Electric Co. in Philadelphia. I have specialized on looking at the future of space travel: In other words, I have been trying to predict for our company what things are going to come about in 5 years, in 10 years, and even in as short a time as 2 years.

I think this is just the opposite end of the time scale from that of Dr. Pierce. He is emphasizing things that you can do now. I have worried about the things you can do later on.

I have spent a large amount of time over this almost 15-year period studying applications of satellite vehicles, that is, their use. This has led into study of problems of design, of reliability, of capability of a satellite, and of the economic considerations; can you afford it, What does it cost you, and what does it get you?

As a result of these studies, I am convinced that the communications satellite is the most important single application of the immediate, close-to-the-earth space vehicle.

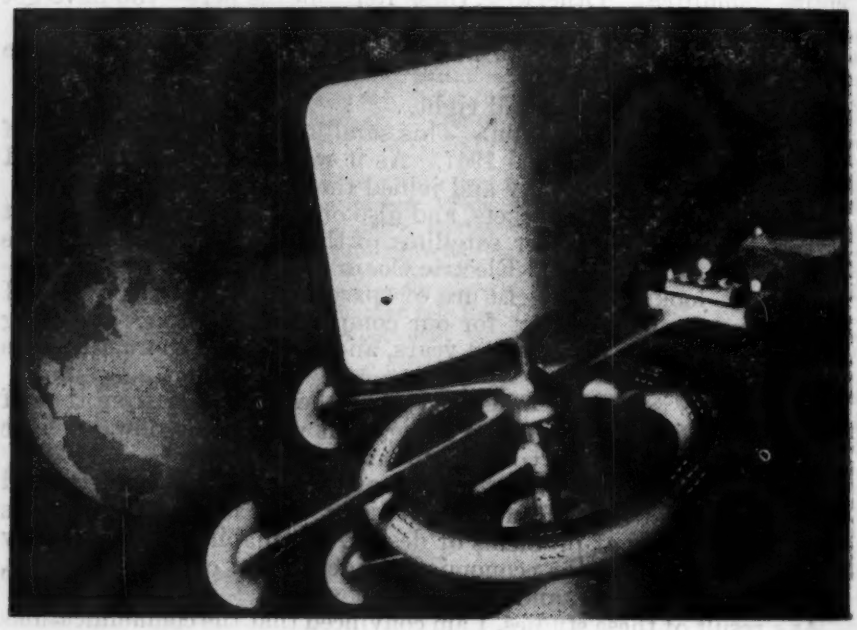
The basic reason for this has already been mentioned by Dr. Pierce, and is the unique altitude of the satellite, which makes long-range communication possible. Associated with this is the fact that this altitude makes it possible to use radio frequencies that cannot be used now for long-range communications. This increases vastly the frequency spectrum available for long-range operation. As Andy Haley can tell us, we are having a very severe problem of channel shortage in communications, and this potential of opening up new frequencies is very important.

Additionally, it appears that in some applications the satellite may be eventually the most economic way of carrying on communications. It is true that a satellite is quite an expensive device. But as it gets larger and larger and carries more communications services, the cost per message or the cost per hour of use becomes smaller and smaller. I will have some notes on this a little later on.

Today, I would like to discuss two different versions of a communications satellite, basically from the standpoint of the satellite rather than communications. The first of these is a very, very large satellite which is some time in the future.

The second one is an active satellite of the type Dr. Pierce mentioned, which can be done with presently available booster rockets.

An artist's conception of the big satellite is shown on the first slide.



I am afraid this is a little dim, so I have some photographs here for the committee.

The CHAIRMAN. We could turn out these central lights here. Would that help?

Mr. HAVILAND. Thank you. In the center of this satellite is a large wheel which contains living quarters for the people who are operating the station and who are maintaining the equipment. This is basically the answer to this problem of reliability in the complex satellite, this reliability problem that Dr. Pierce mentioned. We maintain the satellite equipment just as we do with present radio equipment.

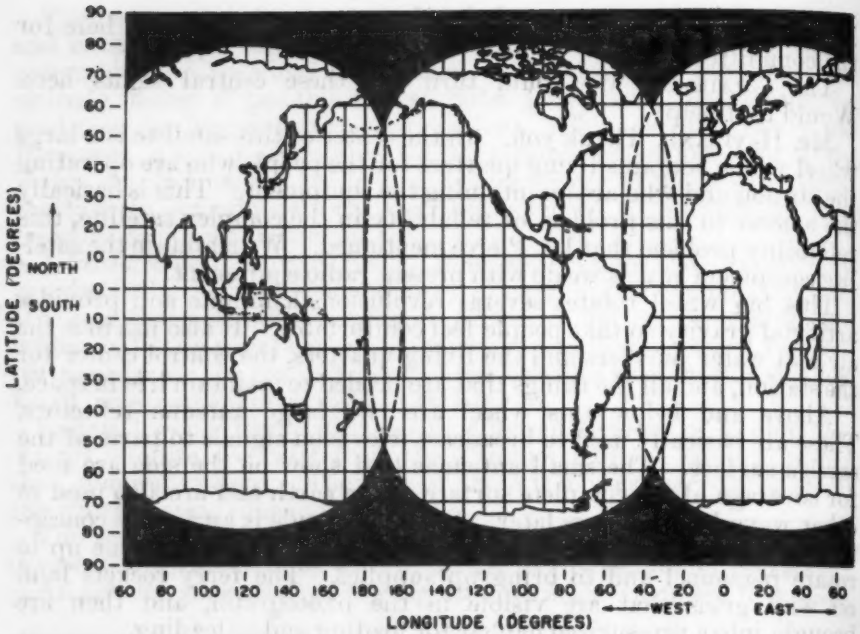
This big wheel rotates several revolutions a minute and provides artificial gravity so that people feel comfortable. It also has in it the air and water purifiers and the living quarters, the control center for the station, and all the things that are needed to maintain life in space.

Above and below this wheel are two large antenna reflectors. These are basically used to broadcast television signals to parts of the earth's surface. The small antennas that show on the side are used for coverage of the complete surface of the earth and are also used in other ways I will discuss later. Over to the side is an artist's conception of the landing platform which allows ferry ships to come up to rotate personnel and to bring up supplies. The ferry rockets land on wire grids that are visible in the photograph, and then are brought into a pressurized hangar for loading and unloading.

In this concept all of the electronic equipment used for the communication service is located in the tube structures that go from the center part of the hub of the wheel on out to the antennas. These tubes do not contain air. Since space is a vacuum, the vacuum tubes which are needed for high power transmitters, based on everything we know now at least, become simple assemblies of metal parts. They don't need the bulb or envelope that we put around the tube now to keep air out of it.

This type of construction increases the reliability of the tube because we have a perfect vacuum. Since the components are accessible, we can go in and unbolt the tube elements and replace them for repair and can do the same thing for other components.

The complete communication network uses three of these satellites in a synchronized orbit.

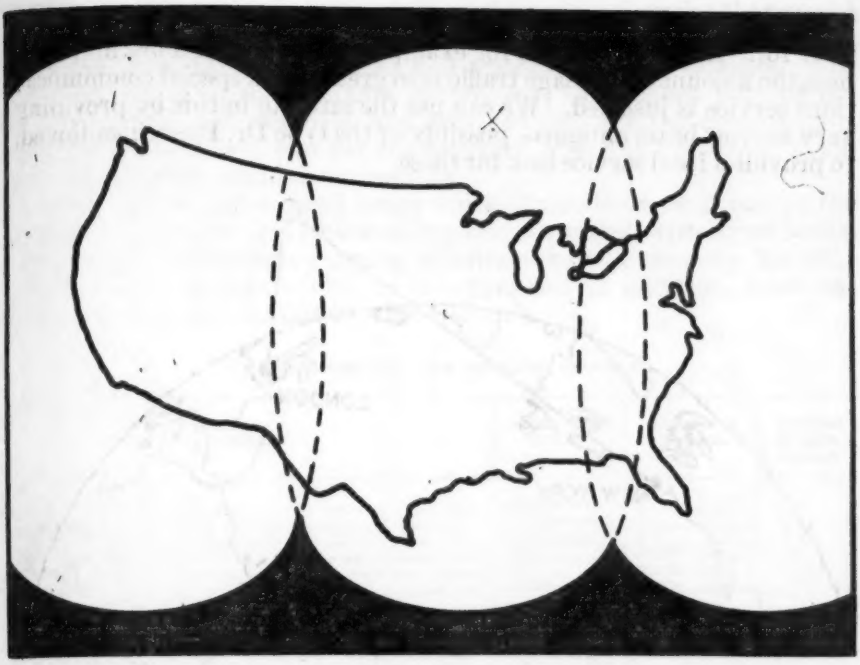


This slide shows how these three stations cover all of the earth with the exception of the very North and South Poles. One satellite is placed over the Equator over South America and gives complete coverage of North and South America. Another one is placed over the East Indies and gives coverage to Asia and Australia. There is another one over Africa which covers Europe, East Asia, and Africa.

These stations can be operated independently or they can be operated as a network. For example, if a program of Mickey Mouse is on, this could be relayed from Hollywood up to one of the stations back to the earth from that one, and also from this station to the others so that anybody on earth with a TV set would be able to pick up this program of Mickey Mouse.

I think you can see the enormous potential for good will, for improvement of international understanding through this opportunity of exchange of cultural information.

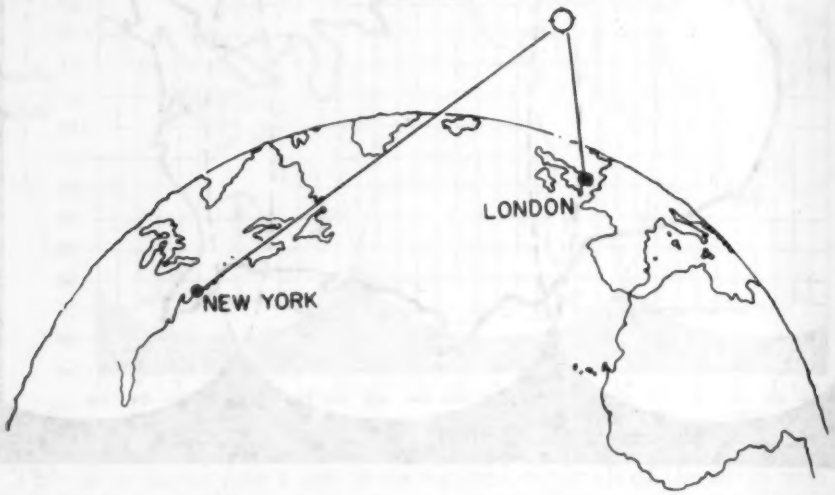
Some areas of the earth's surface are very densely populated and have reached such a state of development that a special quality of service—particularly television service—is justified.



The way we do this is use the same type of satellite, except instead of covering the whole earth, we now just cover a selected part of it. This slide, for example, shows how the antennas cover the eastern part of the United States, the central part, and the western part. This means that for these high-density areas, these highly developed areas, we can also have programs of more local nature.

One thing I would like to emphasize is that a big communications satellite of this type is never going to replace the local station—for example, the one in Washington. The local interest type of programs are much better served by the existing type of station, the ones on the earth's surface. It is the big network programs that cover the country or the world that the big communications satellite is best for.

There are several other classes of service that the satellite could be used for. In certain places, for example, between New York and London, the amount of message traffic is so great that a special communications service is justified. We can use the satellite in this by providing very narrow beam antennas, possibly of the type Dr. Pierce mentioned, to provide a local service link for these.



This slide shows the major worldwide communication centers for oversea telephone services. At present these stations are tied together by cable or by conventional radio, but since they are all within range of vision of one of these three satellites, we can give satellite ties between any of these stations by installing the proper equipment at those points.

This next slide shows a summary of the types of service that would be visualized for this large satellite. There is a general coverage TV. It gives two channels and uses two transmitters per satellite. For high quality TV, the one that covers, say, the eastern part of the United States, six channels, are provided two for the eastern part, two for the western, two for the central. For FM broadcast, again for the complete world, two channels.

Also, we can put a good many voice channels on each one of the television channels. So I have shown here an added capacity of 50,000 telephone conversations running simultaneously, a capacity for 300,000 code-type transmissions, by teletype, and in addition, inter-station relay capacity for 60,000 voice channels.

Large communication satellite services

System	Power transmitter	Number of channels	Number of transmitters
General TV	50 kilowatts	2	4
High-quality TV	50 kilowatts	6	12
FM broadcast	2 kilowatts	2	2
Telephone relay	0.25	50,000 voice	90
Telegraph relay	0.25	300,000 code	10
Intersatellite relay	0.0025	60,000 voice	100

In other words, this satellite has a very large communication capability.

This station is certainly expensive. It is, however, important to remember that once the station is up, it will last for many years. Also, it is important that there are a very large number of communication channels. This means that the cost per channel can be low.

For example, let's assume that for the channels that are listed on the slide we make the charges that are made at present for this type of service. In this case the breakeven cost of the satellite station as compared to conventional communications is about $2 billion. In other words, if this station cost less than $2 billion to construct, and place in the sky in the synchronized orbit, we could reduce the cost of communications below the cost that exists at present. These studies assume that one-half of the income was used for operating expenses and the other half for amortizing the initial cost. That is a very rough way of looking at it, but I think the point is sufficiently clear that a further and detailed study is justified.

Two years ago at the International Astronautical Federation Congress at Barcelona—the congress, incidentally, at which Andy Haley was elected president of the IAF—I presented a technical paper on this type of communications satellite. At this time I stated that the satellite was beyond the reach of current rocket technology.

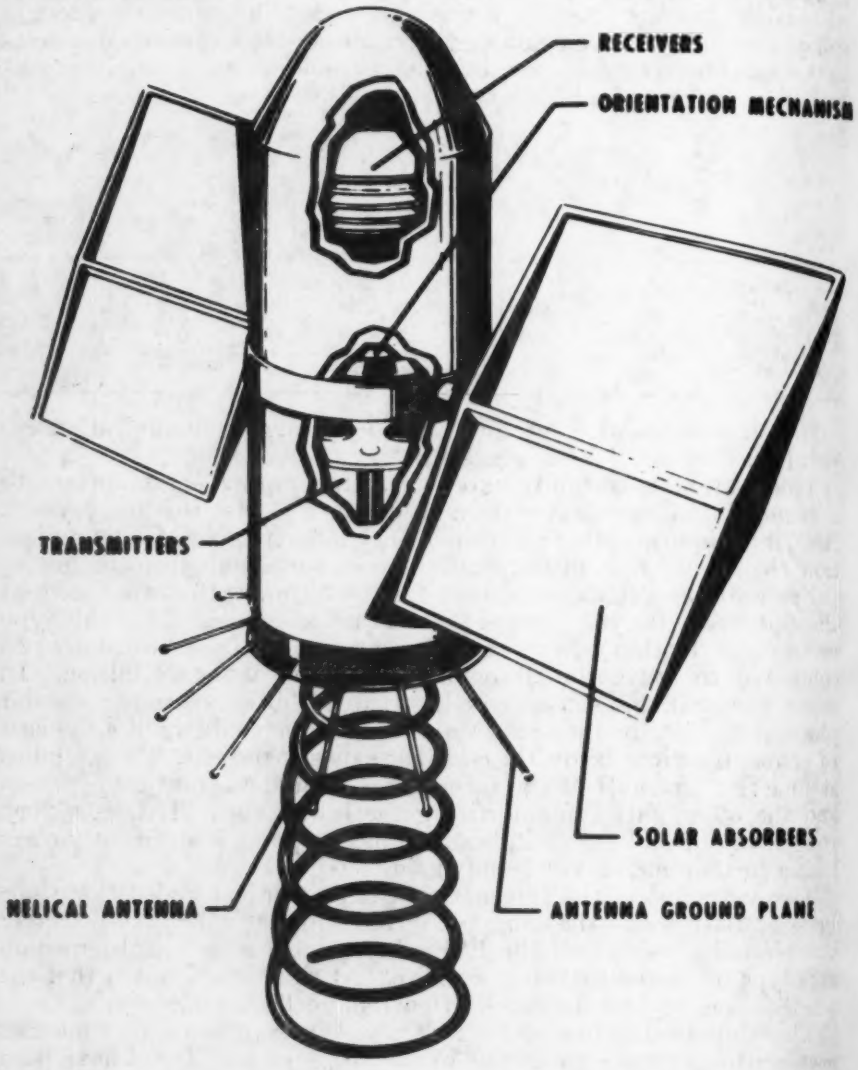
This statement is just no longer true. We have had a very marked acceleration in space programs in the last 2 years. There have been improvements in the concept and in the reduction to practice of large rocket engines. The conclusion I have reached is that this station is now within reach of current rocket technology.

I don't mean by this that we can have it tomorrow, but I mean that we now know how to attack this problem, where the engineering problems are, and how to go about solving them. There will be a number

of years of work before we are able to build this large satellite but it is definitely within reach.

This brings the problem of "Yes, that's fine, but what do we do now? Should we have a communications service right now?"

We have thought some about this. I personally don't work in this field much, but some of my associates have done quite a bit of work. This slide shows a concept of an immediate vehicle. The barrel body



of the vehicle is stabilized so that the helical antenna at the bottom points toward the center of the earth. Stabilization equipment of this kind has been designed and has already flown in a space environment. This antenna is designed to receive and transmit from the visible part of the earth. This isn't an extremely large part of the

earth. The coverage extends about 2,500 miles, and forms a circle about 2,500 miles in radius on the earth underneath the satellite.

The ears on either side of this barrel are the sunpower absorbers which operate the equipment while the satellite is in sunlight, and also charge batteries inside the barrel body for use when the satellite is in the earth's shadow. The ears tilt on hinges and the entire body rotates around so that the satellite is somewhat like a sunflower. It always faces toward the sun to get maximum efficiency of the power system.

The body of this satellite contains four receivers, four transmitters, and the necessary altitude control and power supply equipment. All of these equipments are either now available or under laboratory tests.

This is not a device of the future. This is a device that can be built starting right now.

The capability of this satellite is shown by the slide.

Immediate satellite capabilities

Number of channels	4.
Type of channel	Teletype.
Data capacity	200 simultaneous messages.
Operating altitude	1,000 miles.
Maximum usable range	4,000 miles.
Number to cover Earth	16 satellites.

It is very much less, of course, than the preceding one since there are only four transmitting channels aboard. It can handle only teletype messages or some of the associated types, such as the pulse code message system. Two hundred simultaneous messages can be placed on these four channels.

The satellite would operate at a very low altitude, only 1,000 miles. This is within reach of Atlas-type boosters, for example. The maximum usable communication range is 2,000 miles on either side of the satellite, a total of 4,000 miles altogether.

One of these would be a very useful device. A network of 16 of these in essentially uncontrolled orbits, with some selection, a little more than Dr. Pierce mentioned, would allow us to give almost instantaneous coverage, almost all the time to all the inhabitants of the Earth. There would be a little possibility that you would have to wait as long as 5 seconds to get a message through, but it would be very small.

Sixteen of these satellites seems to be a pretty large number. However, the actual cost of the equipment wouldn't be large, since this barrel itself only weighs about 500 pounds. And even at a cost of $1,000 a pound, the satellite is not an expensive device.

Suppose we assume that we have to replace each one of these satellites once a year, 16 new satellites a year, and that we don't get 100 percent reliability of operation on placing in orbit. If the satellite and launch rocket cost about $2½ million apiece, which is not unreasonable, the cost of maintaining these stations in orbit is about $50 million a year.

The initial cost of placing the satellite service up is somewhat larger, on the order of $100 to $150 million a year.

This is not an insignificant sum, but it is within budget capabilities of both our civilian type of effort and also our military effort.

In summary, it appears that the state and art in communications and astronautics both have reached the point where a useful worldwide communications system can be initiated immediately. Basic know-how is available, and equipment is available, requiring only assembly and some engineering.

Detailed engineering is required to extend this communication by satellites to the point where a worldwide communications system becomes an economical and feasible device.

In view of the need for communication in improving international understanding, I think you will see that there is good reason for considering this communication application as the most important application of the satellite.

Thank you.

The CHAIRMAN. Thank you very much, sir. We appreciate a very fine statement. In accordance with the policy of the committee, we will reserve the questions until we have finished with all of the witnesses.

The next witness we have is Dr. Henri G. Busignies, president, International Telephone & Telegraph Laboratories.

Doctor, do you have a prepared statement?

STATEMENT OF DR. HENRI G. BUSIGNIES, PRESIDENT, INTERNATIONAL TELEPHONE & TELEGRAPH LABORATORIES

Dr. BUSIGNIES. Mr. Chairman, I have a number of notes that I would like to present to the committee

The CHAIRMAN. All right, sir. If you will proceed, sir, pull the microphone up a little closer because the committee is spread out and it is a little hard to reach from one side of the room to the other.

Dr. BUSIGNIES. Yes, Mr. Chairman.

As I am responsible for the research and development laboratories of the International Telephone & Telegraph Corp. in the United States, I follow with my staff all possible future developments of the art of communication. We have followed for some time the problem of communicating with satellites. ITT is operating a worldwide communications system. It is therefore quite indicated to follow the situation technically quite closely.

Right after the Second World War, in 1946 we only had one satellite available. It was the Moon. We studied the possibility of using the Moon as a relay station for communication on a worldwide basis and published a paper around that time in the Proceedings of the Institute of Radio Engineers. I can also say that our interest continued after that date in the use of satellites for long-distance, worldwide communication and also for military communications, as we have been working for many years in helping the armed services in their communication problems.

So as the manmade satellites became a reality, we increased our research and development effort in the field of communication with satellites. As I have the good luck of following the very good introduction of the subject made by the two previous speakers, I will not get into what they have covered very well of the generalities, and I will get back quickly into the subject of our studies.

Mr. FULTON. With the chairman's permission, could I ask that the witness give his background of education and likewise the corpora-

tions of the company and what connection your laboratories have with the company?

Dr. BUSIGNIES. Certainly, sir.

ITT Laboratories are a division of the International Telephone & Telegraph Corp. I am the president of ITT Laboratories. I have been working for 30 years with the ITT system, and approximately the last 20 years, in the United States in various capacities, always technical, always research and development.

My formal education was obtained in France as an electrical engineer. I have an honorary doctor of science degree in the United States.

All my life I have worked in radio navigation and radar systems, in very early radar systems, and in radio communication later on. But all during that time I have been closely in touch with all the technical problems of communication in the laboratories of the ITT system.

Mr. FULTON. Would you describe shortly the ITT system and in what countries it operates and in what States it is incorporated?

Dr. BUSIGNIES. The I.T. & T. system is a completely American-owned company, it operates in the field of research and development and manufacture of communication and electronic equipment in the United States, basically, and also in a large number of countries, exclusive of the Iron Curtain countries.

Mr. FULTON. At a later time will you supply those for the record?

Dr. BUSIGNIES. Yes; certainly.

The CHAIRMAN. You operate all over the world, but you can give us the individual countries for the record if you will.

Dr. BUSIGNIES. Absolutely, sir. It is a long list. I can make that available.

The CHAIRMAN. How many countries do you operate in?

Dr. BUSIGNIES. More than 40.

The CHAIRMAN. Forty?

Dr. BUSIGNIES. Yes; we also cover research and development, manufacture of communication and electronic equipment, in addition to the part of the I.T. & T. system which is a worldwide network of communications.

Mr. FULTON. So you do both things. You do research and development, supply equipment, as well as operate in the various countries. That is what I would like to have you later put on the record.

Dr. BUSIGNIES. Certainly.

I am sorry I didn't detail this, because I had no intention to emphasize the position of the company and was only thinking about making a statement from a technical viewpoint.

Mr. FULTON. It gives us your background, which is helpful.

(The matter referred to is as follows:)

INTERNATIONAL TELEPHONE & TELEGRAPH CORP.

Founded in 1920

Largest American-owned international enterprise engaged in the development, manufacture, installation, operation and maintenance of electronic and telecommunication systems and equipment.

More than 130,000 employees in 43 countries.

Argentina	Germany	Pakistan
Australia	Ghana	Peru
Austria	Greece	Portugal
Belgium	*India*	*Puerto Rico*
Bolivia	Iran	Rhodesia
Brazil	*Iraq*	*Scotland*
Canada	Ireland	Spain
Ceylon	Italy	Sweden
Chile	Japan	Switzerland
Cuba	Kenya	Turkey
Denmark	Mexico	Venezuela
Egypt	Netherlands	West Indies
England	New Zealand	United States
Finland	Norway	
France	Nyasaland	

Total revenues for 1958: $703,010,679.
Consolidated net income: $26,600,168.
Total sales: $635,153,122.
Telephone and radio operating revenues: $52,298,323.
Earnings per share (adjusted for 2-to-1 stock split): $1.85.
Dividends per share (adjusted for 2-to-1 stock split): $0.90.
Net current assets: $233,962,786.
Total orders on hand: $511,000,000.

(Above figure—$511,000,000—does not give effect to certain large contracts which have been awarded recently, and on which the final amounts are not yet determined. Such contracts include 480–L, air communication support system; 465–L, worldwide control system for the Strategic Air Command; Project Turnkey, the Government's fully mechanized post office, and the mission and traffic control subsystem for the F–108 interceptor.)

ITT headquarters—67 Broad Street, New York City.

U.S. divisions and subsidiaries

ITT Federal (4,500 employees): 1,200,000 square feet of floor space at plants in Clifton, N.J., Fort Wayne, Ind., San Fernando, Calif.; manufacturer of electronic systems and equipment.

Kellogg Switchboard & Supply Co. (3,500 employees): 700,000 square feet of floor space at plants in Chicago and Raleigh, N.C.; manufacturer of telephone equipment and systems.

ITT Components Division (1,000 employees): 300,000 square feet of floor space at plants in Clifton, N.J., Roanoke, Va.; manufacturer of electron tubes, rectifiers, other components.

Federal Electric Corp. (2,300 employees): ITT service organization. Maintains DEW line and White Alice communication projects. Headquarters in Paramus, N.J.

Royal Electric Corp. (1,100 employees): 480,000 square feet of floor space at plants in Pawtucket and Woonsocket, R.I.; manufacturer of cable, wire, and electrical devices.

American Cables & Radio Corp.: Operators of largest American-owned international telegraph system. Principal A.C. & R. subsidiaries are All American Cables, Inc., the Commercial Cable Co., Mackay Radio & Telegraph Co.; headquarters in New York City.

Intelex Systems: Developer of automatic systems, electrical and pneumatic. Located in New York City and Rochelle Park, N.J.

Industrial products division: Equipment for aircraft, railroads, industrial television. Headquarters in San Fernando, Calif.

ITT Laboratories: (See below.)

Foreign divisions and subsidiaries

International Standard Electric Corp., wholly owned by ITT, directs the parent company's manufacturing, research, sales, and licensing activities outside the United States.

ISE is responsible for 23 principal organizations in 19 foreign countries; offices in more than 40 countries; 13,500,000 square feet of floor space; 93,000 employees.

Not included are statistics on International Electric Corp., formed recently by ITT to handle 465–L project, and new unnamed subsidiary being formed to handle 480–L project.

ITT LABORATORIES

Principal installations: Nutley, N.J., Fort Wayne, Ind., San Fernando, Calif., Palo Alto, Calif., Atlanta, Ga.
Founded 1940: 700,000 square feet, 3,200 employees (1,100 engineers and scientists).
Orders on hand: $36 million.

Fields of interest
Missile and space systems.
Electronic countermeasures.
Avionics (air navigation).
Radar.
Data processing.
Wire and radio communications systems.
Physical sciences, components, and instrumentation.
Electron tubes.

Some important developments
TACAN (tactical air navigation).
VORTAC (new worldwide air navigation system).
ILAS (instrument low approach system for aircraft).
Over-the-horizon microwave radio (for long distance TV and telephone).
Ace High (communication system for SHAPE).
Electronic automatic message recorder for toll-call telephone billing.
Electronic ground-control or airborne guidance for the Bomarc, Talos, Terrier, Sparrow, Meteor, Titan, Atlas, and Lacrosse missiles.

Dr. BUSIGNIES. I would like to divide the problem of satellite communication into two aspects, that is, the radio and the electronic aspects of the problem, and the vehicle and launching problem. I would like to say that as far as the radio and electronic aspects of the problem are concerned, we can at this time solve the problem of long-distance communications through satellites with the existing techniques and the only aspect of these techniques which would have to retain our attention particularly would be the life of the components involved in the material installed in the satellite itself.

This is an aspect on which a substantial amount of work would have to be done in order to insure the operation of the satellite for a substantial and economic period of time.

Outside of this particular problem which can be solved in the next few years, we have solutions available in the communications industry to start making immediately a system of communication using satellites. The next problem is to take the space part of this system and place it at the proper altitude and the proper orbit to satisfy the requirements of the system.

I should like to say at this moment that we have been working in connection with the Astrophysics Development Division of Curtiss-Wright on the vehicle aspect of this project and lately with the Aerojet General Co., which of course have considerable background in that area.

They have two additional problems to solve which have not been solved yet. After a satellite is placed approximately in the area where it is to operate and if it is to be active—that is, that it would carry equipment which would receive and transmit signals in contrast with the passive reflectors that Dr. Pierce has mentioned before, then this satellite, this vehicle needs to have the proper attitude with respect to the center of the Earth.

A control system has to be designed to keep this attitude proper. If we want to have a satellite at a fixed point above a certain part of

the Earth—that is, rotating round the Earth at the same speed as the Earth, what is called a 24-hour satellite—then we also need a control system to maintain it there. Very minute forces need to be applied to it so that it will not drift and get out of the position relative to the Earth assigned to it.

After studying the possibilities of passive satellites—that is, the big spheres which will reflect radio signals, or the satellites in motion with respect to the Earth, we selected as an exercise the study of the 24-hour satellite system; that is the one in which we have a satellite in a fixed position with respect to a certain point of the Earth—fixed at least on a longitude basis. It could move somewhat on a latitude basis without causing any problem.

We selected this particular system as an exercise for our research and development group to prepare a study because we thought that not only could it have commercial applications, but it could also result in systems which could be useful to the armed services in their communication problems—for instance, the problem of the Air Force in communicating with the arctic regions.

In using a fixed satellite, a 24-hour satellite, we could have three to cover the whole world—but using one we could cover North and South America, western Europe and Africa with one airborne machine.

Mr. McDonough. Would the area on the Earth depend upon the elevation?

Dr. Busignies. Yes, but 22,000 miles is required to have a fixed satellite with respect to the Earth. In other words, in order to have the speed with which it rotates at the same speed as the Earth, it has to be at an elevation of 22,300 miles from the surface of the Earth. Then with a control system moving it slightly back and forth, it can be kept in that position.

We also selected a number of variable stations in this broad area, and we could starting of course with 2, go up to 8, 12, or 24 stations. We could go to 46. The number of countries covered by this area is approximately 46 countries.

However, in our exercise we studied the case of 2 to 24 positions. We tried to conceive of a relatively simple active repeater to be carried by this satellite which would permit all these stations to communicate together with a number of voice channels. Starting with 48 duplex channels between any of the points to be connected, we studied it up to 1,000 voice channels and one television channel.

In the case of the 48 duplex channels between any of these points, we would need a power of half a watt transmitted by the radio system of the satellite. In case of 500 duplex channels, we would need a power of the order of 5 to 6 watts transmitted. It could also be 250 duplex channels plus a television link—1 only.

This would make use of modulation techniques that we are quite familiar with involving frequency modulation for each station and a pulse code modulation to carry the voice or data, which combination gives a good deal of protection against noise and jamming.

The power supply for it would furnish between 80 and 150 watts and would weigh—depending upon the service—between 55 and 100 pounds. The total weight of this airborne payload is 760 pounds as considered at this time.

The ground transmitters and receivers would be working on 2,000 megacycles with dual equipment and large tracking antennas, 60 feet in diameter. Use would be made of the latest techniques of reducing noise as mentioned by Dr. Pierce.

We went a little further at that point as the study began to shape up into a system which could provide the proper number of voice circuits between many countries requiring such service now, and we had a quick look at the economical situation on such a project.

Excluding the cost of research and development, which is of course quite substantial, and looking at the cost of the ground installations and the cost to place one satellite in operation, we reached very approximate figures as follows: For 12 ground installations involving terminal facilities and a computer system to permit the handling of traffic the cost of the plant is $24 million, which plant would of course, work for many years. We don't think the first satellite would live more than 2 years—at least we should not take the risk of planning a system for more than this because we still do not know about the life of some of the components.

The cost of the missile and satellite was estimated at $4 million to place it there. However, we considered that we could have four misfires before having one in operation. That multiplies the cost of $4 million by five, making a total of $20 million for the first attempt.

On the second attempt 2 years later, we think we could limit the misfires to two, and have a life of 4 years. On the third attempt, after 6 years, we think that we could also succeed after the second attempt, but have a life now of 14 years, as we will have solved many of the life of components problems. Those, of course, are assumptions that can be discussed.

Then on a 20-year basis we would have a total cost of $56 million for the plant only, exclusive of research and development, and exclusive of the cost of launching.

On this basis, the cost per channel mile for the plant would vary between $665 in the case of 48 duplex channels to a cost of $55 only in the case of 250 duplex channels, plus 1 television channel.

In comparing these costs with the cost of a present communications system like the submarine cable, we would find that the cost of a submarine cable plant is between those two values. We do not claim that this is a very accurate statement of cost, but we had to establish a base to see how, from a commercial viewpoint, such a system could compare with existing techniques.

Apart from the commercial aspects and as we have been working for a long period of time for the armed services in helping them with their communication problems, we also feel that these techniques may be applied to solve their problems.

For instance, the Air Force has to spend a great deal to communicate in the arctic region due to the rough conditions there. I think the cost is of the order of 10 times the cost of communications in other regions.

A satellite communications system could be quite helpful for communicating in the Arctic area.

However, the satellite system we described here would not cover properly the arctic area. In order to cover it better, one would have to have a system of two or three satellites on a 45-degree orbit

and one would be south of the Equator while the other would be north on a meridian, and they would be alternating in providing service to the arctic area.

The Navy has communications problems on a global basis with ships and bases. Traditionally the Army, that is the Signal Corps, have provided for communications between fixed points. We hope that some of these studies could be helpful in connection with some of their problems.

We have given consideration to passive satellites—that is, the kind which is not energized locally, but may have to be energized anyway to control their stay at the proper location with respect to Earth. We know and we are very familiar with the possibilities of jamming of active satellites, even though one 24-hour satellite covering the area that I have mentioned could be positioned in such a way that it couldn't be seen from Soviet Union territories. That is not, of course, a full protection at all, but at least it is an advantage.

The other solutions, particularly the entirely passive fast-orbiting satellites have been studied and some documents published by Dr. Pierce, there is no point for myself to mention their possibilities. I particularly tried in this presentation to give an example of a possible worldwide communications system on which work could be started immediately, at least as far as the radio equipment is concerned. All radio problems can be solved at present, and communication of that type could be tested in 1962.

We do not underestimate the problems in making the vehicle and controlling it. This would be the major problem to solve. But we now have reached a point where satellite communication becomes possible. We continue to carry research work in this area, particularly in the radio tube aspect—that is, to solve the problems of the long-life transmitting tube which would be needed for an active satellite and that of the other components necessary to keep the radio satellite going for a long time. We work as well on parametric amplifiers and other low noise amplifiers necessary for perfecting such communications.

We have been actively working on large ground communication systems using a large amount of radio power, greater than needed for this. For instance, we installed the Florida-Cuba television microwave link, linking the United States with Cuba for television, involving large parabolic antennas of the type mentioned here radiating in the microwave region up to 10 kilowatts of radio power on a very wide band of frequencies. It is with this technical background that we pursued these preliminary studies of the problem of satellite communication.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Doctor. You made a very learned statement. I want to apologize to you for your having been interrupted a couple of times during your statement. But that was due to the fact we were late in getting started this morning.

I want to suggest to the members of the committee, we have two more witnesses and then we want an opportunity to ask questions of some of the witnesses who have already testified. It seems to me we can't possibly finish this morning. I checked up to see what we have

on the floor. There are two bills from the Armed Services Committee, one on retired pay and the other on promotions. The retired pay bill has a 2-hour debate. Therefore I suggest if there is no objection we adjourn until 2 o'clock.

Then we can finish with these witnesses today. Tomorrow we have a rather heavy schedule. If we carry any of the witnesses over we wouldn't be able to reach them tomorrow.

Mr. FULTON. Could we take one more witness?

The CHAIRMAN. We could proceed that way, but then if we did, we would have to adjourn until 2:30. It is just about as broad as it is long—whichever you wish. It seems to me better to adjourn now and then we could get in the 2 hours general debate there and hear all of the witnesses.

So if there is no objection, the committee will stand adjourned until 2 p.m. today.

(Whereupon, at 12 noon the committee adjourned, to reconvene at 2 p.m.)

AFTERNOON SESSION

The committee met again at 2:05 p.m. in the caucus room of the Old House Office Building, Hon. Overton Brooks, chairman, presiding.

The CHAIRMAN. The committee will please come to order.

I think we had better proceed promptly because there is a possibility of another rollcall this afternoon. So we are anxious to get the witnesses before the committee.

At this time I promised my colleague, Mr. Anfuso, to permit him the privilege of presenting one of his constituents and an outstanding American, and that is Mr. Andrew G. Haley, president of the International Astronautical Federation.

Will you take over?

Mr. ANFUSO. Thank you, Mr. Chairman. I might say to the committee that Mr. Haley is not only a great American, as you have just stated, but he is an international figure. He has traveled the whole wide world in the interests of science, and it would take me all day to speak about his many qualities and virtues.

I for one—and I am sure all the members of the committee—am acquainted with your work and am extremely grateful to you for your splendid cooperation since the inception of this committee. You and your associates are to be congratulated for your pioneering efforts in the field of science and astronautics.

You gentlemen have been years and years ahead of our Government in your thinking, vision, and practical experiments.

I might say that in spite of the stiff cross-examination which I understand my colleague from Pennsylvania, Mr. Fulton, has promised, that in my opinion you are a great American and that this country will long be indebted to you and all of you gentlemen sitting here today.

Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Haley, do you have a prepared statement?

Mr. FULTON. May I join with my friend from New York in cordially welcoming Mr. Haley. He always gives us good replies on every cross-examination he has ever received.

STATEMENT OF ANDREW G. HALEY, PRESIDENT, INTERNATIONAL ASTRONAUTICAL FEDERATION

Mr. HALEY. First, Mr. Chairman, if you will forgive me, I must say that I feel deeply honored by the introduction of Congressman Anfuso, whom I have known for many, many years because of his effective work in stemming the tide of communism in Western Europe—and, in fact, being one of the most important persons in saving Western civilization in that area of the world.

Congressman Fulton—of course it is always nice to see Congressman Fulton, especially after our very nice experience in Amsterdam, the hard work we did there.

As to the statement, I have a prepared statement which is long. I hope that my verbal statement here will be, comparatively speaking, as short as the prepared statement is long.

The CHAIRMAN. I want to say this. The committee will be very happy to have your lengthy prepared statement. I am going to recommend to all the members of the committee that they take this prepared statement to their respective domiciles tonight and go over it with leisure and with the attentiveness it deserves.

In the meantime, if you could give us a summarization of what you have in the prepared statement, it will be of great help to us.

Mr. FULTON. I move that the statement be put in the record at this point.

Mr. ANFUSO. I second the motion.

The CHAIRMAN. It doesn't take a motion. If there is no objection, it is so ordered.

(The testimony of Andrew G. Haley is as follows:)

Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington 25, D.C.

FCC 59-16
67510

In the Matter of Revision of the Radio Regulations of the International Telecommunication Union

Docket No. 12263

SIXTEENTH NOTICE OF INQUIRY

1. The Fifth Notice of Inquiry in this proceeding included draft proposals for an international table of frequency allocations. That table made no specific provision for "space" communications. The Commission has reviewed the comments received thereon, the work of the Department of State Preparatory Committees concerned, and recent definitive "space" communication proposals brought to its attention by cognizant Government agencies and has concluded that the aforementioned table in the Fifth Notice of Inquiry in this proceeding should be amended so as to provide for space communications.

2. The Commission's revised proposal is designed to accommodate requirements for space communications and to provide a necessary minimum of definitions for the proposed new Earth/Space and Space services. Because of the urgency in formulating definitive U.S. proposals to be submitted to the International Telecommunication Union, a very limited time is being provided for comments on the proposals attached hereto. Upon receipt of such comments, the Commission's representative on Department of State Preparatory Commit-

tee III will submit the attached proposal to that Committee, together with any amendments thereto which may appear desirable in the light of the comments received in response to this Notice of Inquiry.

3. The Commission emphasizes that it has not taken a final position with respect to this matter. Following consideration of the aforementioned revised proposal by the appropriate Department of State Preparatory Committees, the Commission's recommendations will then be made known to the Department of State which has the overall responsibility for formulating the position of the United States in these matters. It should be noted that the Department of State receives recommendations not only from the Commission but also from other interested agencies of the Government.

4. Any interested person is invited to file comments with the Commission concerning this matter on or before January 21, 1959. In view of the necessity for preparing the United States position at the earliest possible time, the Commission does not expect to be able to grant an extension of time for filing comments. In accordance with the provisions of Section 1.54 of the Commission's Rules, an original and fourteen (14) copies of all comments shall be furnished to the Commission.

FEDERAL COMMUNICATIONS COMMISSION,
MARY JANE MORRIS, *Secretary.*

Attachment
Adopted: January 7, 1959
Released: January 8, 1959

APPENDIX 1

ARTICLE I

DEFINITIONS

6b *Objects in Space:* Natural or artificial objects such as the moon, planets, satellites and space vehicles, maintaining sustained motion beyond the major portion of the earth's atmosphere. Objects in space do not include such objects as conventional aircraft, balloons, missiles or rockets which are limited to flight between points on the earth's surface.

Reason: To define a term which is used in these proposals.

20a *Earth/Space Service:* A service of radiocommunication between earth and objects in space.

Reason: To define a new service set forth in these proposals.

20b *Space Service:* A service of radiocommunication between objects in space, excluding earth.

Reason: To define a new service set forth in these proposals.

39a *Earth Station:* A station in the Earth/Space Service located upon the earth's surface.

Reason: To define a term set forth in these proposals.

39b *Space Station:* A station in either the Earth/Space or the Space Service located on an object in space.

Reason: To define a term set forth in these proposals.

APPENDIX 2

Frequency band megacycles	Allocation to services	Footnotes
25.6–25.65	Earth/space	
100–150		The space and/or Earth/space services have a stated requirement for frequency accommodations between 100 and 150 Mcs. Study is being given to the possibility of meeting this requirement in frequency bands presently allocated exclusively to Government services in that portion of the spectrum.
1700–1725	a. Earth/space [1] b. Fixed c. Mobile d. Space [1]	218D: In the band 1700–1725 Mcs., the fixed and mobile services shall not cause harmful interference to the Earth/space and space services. This band is established primarily for communications with, or between, Earth and space stations.
1825–1850	a. Earth/space [1] b. Fixed c. Mobile d. Space [1]	218E: In the band 1825–1850 Mcs., the fixed and mobile services shall not cause harmful interference to the Earth/space and space services. This band is established primarily for communications with, or between, Earth and space stations.
2275–2300	a. Earth/space [1] b. Fixed c. Mobile d. Space [1]	218F: In the band 2275–2300 Mcs., the fixed and mobile services shall not cause harmful interference to the Earth/space and space services. This band is established primarily for communications with, or between, Earth and space stations.
8300–8400	a. Earth/space [1] b. Fixed c. Mobile d. Space [1]	228B: In the band 8300–8400 Mcs., the fixed and mobile services shall not cause harmful interference to the Earth/space and space services. This band is established primarily for communications with, or between, Earth and space stations.
15150–15250	a. Earth/space [1] b. Fixed c. Mobile d. Space [1]	231F: In the band 15150–15250 Mcs., the fixed and mobile services shall not cause harmful interference to the Earth/space and space services. This band is established primarily for communications with, or between, Earth and space stations.
31500–31800	a. Earth/space [1] b. Fixed c. Mobile d. Space [1]	231G: In the band 31500–31800 Mcs., the fixed and mobile services shall not cause harmful interference to the Earth/space and space services. This band is established primarily for communications with, or between, Earth and space stations.

[1] The U.S. considers that this allocation should be on a worldwide basis.

Before the

FEDERAL COMMUNICATIONS COMMISSION

Washington 25, D.C.

In the matter of Revision of the Radio Regulations of the International Telecommunication Union.

Docket No. 12263

COMMENTS OF AMERICAN ROCKET SOCIETY AS TO THE SIXTEENTH NOTICE OF INQUIRY

American Rocket Society, by its General Counsel, submits its comments on the matters set out in the Sixteenth Notice of Inquiry, released January 8, 1959.

INTRODUCTION

While the American Rocket Society highly appreciates the Commission's proposals for the establishment of space radio services and stations and the allocation of radio frequencies thereto,[1] nevertheless the Society strongly urges that certain vital modifications and additions described herein be incorporated in the Commission's proposals before they are transmitted to the Department of State Preparatory Committee III for the use of the Department in preparing for the 1959 Radio Conference in Geneva.

[1] Col. John P. Stapp, president of the American Rocket Society, has advised counsel by telegram that he "indorses and approves proposal submitted under Docket No. 12263 and Appendix."

The Society is participating in the work of that Preparatory Committee, and will continue to make recommendations for the implementation of the proposals outlined in the Sixteenth Notice and in these comments.

The Society has participated in this proceeding and in other formal proceedings involving the use of radio in space flight. The Society's earlier comments and proposals are incorporated herein by reference.[2]

The General Counsel of the Society has solicited comments on the Sixteenth Notice from a group of scientists and engineers who comment as individuals and not in their official capacities [see list in Appendix 1]. Many of these scientists are on the staffs of Federal agencies such as the National Aeronautics and Space Administration, the Advance Research Projects Agency, the Army Ballistic Missile Agency, the Naval Research Laboratory, the Air Research and Development Command, the National Bureau of Standards, and others; Industrial, educational and research centers; communications carriers and radio system engineering firms; and the broadcasting and communication industries, but, as stated above, their views are individual and unofficial.

Written data were secured from some thirty-five individuals, and the views of these members of the group were reviewed and coordinated by a space radio panel of the American Rocket Society consisting of:

Mr. George P. Adair[3]
Dr. Dana K. Bailey[4]
Mr. J. Carl Seddon[5]
Dr. Alan Shapley[6]
Mr. James O. Spriggs[7]

The following comments are based on the information made available to counsel by the individuals and the panel described above.

I. DEFINITIONS

With three significant exceptions, the definitions contained in the Sixteenth Notice of Inquiry are considered to be adequate for the Commission's announced purpose, namely to provide a "necessary minimum of definitions" for the proposed new space radio services. The panel members are of the view, however, that the definition of "Objects in Space" (6b) should be broadened; that the definition of "Earth Station" (39a) should also be enlarged; and that an entirely new class of service should be established to be known as the "Earth/Space/Earth Service", and provision should be made for "Earth/Space/Earth Stations" to operate in the new service.

1. The definition of "objects in space"

Rear Admiral John E. Clark[8] urges that the words "or space vehicles during their launching phase" be included after "* * * on the earth's surface" in the proposed definition of Objects in Space (6b). Admiral Clark states in support of this suggestion that "It is considered that the interference problems in the frequency regions used during the launching phase for instrumentation purposes, which are not associated with the operating part of the satellite or space vehicle flight, can be isolated on an area basis sufficiently well to avoid serious interference problems."

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[2] Reference is made to the following:
1. Appearance and Comments of American Rocket Society, FCC Docket No. 11997, captioned "Statutory Inquiry into the Allocation of Frequencies to the Various Non-Governmental Services in the Radio Spectrum between 25 and 890 mcs.," filed Nov. 25, 1957.
2. Comments of American Rocket Society on the First Notice of Inquiry in Docket No. 12263, captioned "Revision of Radio Regulations of International Telecommunication Union," filed Jan. 23, 1958.
3. Comments of American Rocket Society as to the Second Notice of Inquiry, Docket No. 12263, filed Mar. 27, 1958.
4. Comments of the American Rocket Society as to the Fifth Notice of Inquiry, Docket No. 12263, filed May 15, 1958.
5. Statement of Proposed Evidence for Docket No. 11997, filed by American Rocket Society, Oct. 31, 1958.

[3] Consulting Radio Engineer, George P. Adair Engineering Company.
[4] International Chairman, CCIR Study Group VI; Page Communications Engineers, Inc.
[5] Physicist, Upper Atmosphere Division, National Aeronautics and Space Administration.
[6] Chief, Sun-Earth Relationships Research Section, National Bureau of Standards.
[7] Special Assistant to Deputy Director, Advanced Research Projects Agency.
[8] Deputy Director, Advanced Research Projects Agency, Department of Defense.

2. The definition of "earth station"

Mr. James R. Dempsey [9] proposes that the definition of "Earth Station" (39a) be revised to read as follows:

"A station in the Earth/Space service located upon the earth's surface, *or on objects such as conventional aircraft, balloons, missiles or rockets which are limited to flight between points on the earth's surface, which are engaged in a radio communication service with objects in space.*" [Italic indicates additional language proposed.]

Mr. Dempsey states [and the panel agrees] that "it is likely that it may be desirous to relay communications from the earth's surface to balloons or other aircraft in the upper atmosphere at VHF and subsequently relay the communication to objects in space."

Furthermore, Mr. Krafft Ehricke [10] states:

"In our studies we found that communicating with a space probe from a balloon or aircraft may be preferable in some cases to communication from the surface."

It should be pointed out, with respect to Mr. Dempsey's proposal, that in at least one instance a space vehicle has been launched from a balloon in the earth's atmosphere, rather than from the surface of the earth. In Project Farside, early in 1958, a rocket was fired from a balloon in the earth's atmosphere above the Pacific Ocean. Similarly, the launching of rockets and missiles from large "mother aircraft" flying high in the earth's atmosphere is presently in an advanced stage of development. In that type of situation a radio station which is operating in the balloon or aircraft, for control, guidance or other transmission to the rocket or missile, would not fall within the definition proposed by the Commission, since the transmitter would not be located on the earth's surface. It is apparent that this type of radiocommunication should be included within the definition of "Earth Station".

3. "Earth/space/earth service" and "earth/space/earth stations"

Dr. John R. Pierce [11] states that "there is an important field of application for satellite repeaters to provide communication between points on earth. The bands proposed are far too narrow for a useful broadband service of this sort. Many hundreds of megacycles will ultimately be required. Also, frequencies above 10,000 mc. are ill-suited for satellite relays."

[Dr. Pierce's paper on Orbital Radio Relays was filed by the Society with its Appearance and Comments in Docket No. 11997, on November 25, 1957. This paper is most helpful as it contains a detailed discussion of the feasibility of the type of operation to which Dr. Pierce makes reference in the above statement.]

After extended discussion, the panel agreed that a definition for the "Earth/Space/Earth Service" should be recommended for inclusion in the Commission's proposals. The panel agreed on the following language:

"*Earth/Space/Earth Service: A service of radiocommunication between positions on earth utilizing objects in space.*"

The corresponding "Earth/Space/Earth Station" would be defined as "a station in the "Earth/Space/Earth Service".

Further support for Dr. Pierce's proposal was given by Mr. James L. Middlebrooks.[12] He comments that the definitions as presently written "do not directly cover the use of natural or artificial objects in space as pure passive reflectors. The use of 'space' objects as passive reflectors would not require either transmitting or receiving apparatus to be located on the 'space' object contributing to the reflection. I assume that in the future we will find more and more rocket hardware, such as casings, nose cones, lightweight aluminum spheres (inflated in space) and other similar artificial objects orbiting in space. If such is the case, I am sure someone will want to use these objects as passive reflectors to redirect radiocommunications."

Mr. Middlebrooks also foresees some use of reflections from gases trailing natural objects, and suggests that at a later date the definition of "Objects in Space" may have to be changed to encompass such gaseous reflector means.

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[9] Vice President, Convair-Astronautics, a Division of General Dynamics Corporation.
[10] Chief of Pre-Design & Systems Analysis, Convair-Astronautics, a Division of General Dynamics Corporation.
[11] Director of Research-Communications Principles, Bell Telephone Laboratories, Incorporated.
[12] Vice President and Director of Engineering Planning, King Broadcasting Company (Stations KING, KING–FM, KING–TV, KGW, KGW–TV, KREM, KREM–FM, KREM–TV).

Mr. Middlebrooks has made the following statement with respect to this matter:

"The proposed definitions relate only to natural or artificial objects. Radiocommunications using reflections from gases trailing natural objects such as meteors are providing interesting and challenging radiocommunication circuits employing frequencies which heretofore have been considered useless for earth-to-earth communications. Is it beyond the realm of possibility that these gases from natural objects or gases released from rockets, orbiting in space, will not be utilized in 'space' radiocommunication?"

II. FREQUENCY ALLOCATIONS AND BANDWIDTHS

The Commission's proposal for frequency allocations is a laudable start toward solution of a major international problem. Within the framework of the pertinent international treaties, provisions must be made for the lawful use of radio frequencies for all forms of space radiocommunications. This requirement of international law has been observed only once by any nation since the launching of Sputnik I. United States and U.S.S.R. satellites alike, one or the other, have broadcast on, for example, the most sensitive of all frequencies, the worldwide allocated "standard frequency", better known as the "time signal" frequency; and also on the video part of Television Channel 8, used in Indianapolis, Des Moines, Syracuse, Cleveland, Portland, Dallas, Houston, and numerous other American and European cities.

Many radio frequencies are needed for communication between earth and vehicles in space, and between vehicles in space and earth; between earth and positions in space; and positions in space and earth; between two or more positions in space; between two or more space vehicles. Radio frequencies are essential, not only for all such forms of communication but also for numerous other purposes such as telemetering, tracking, guidance, radiopositioning (radar), and so on.

The overall subject of world agreement on the use of radio frequencies in space has been considered at length in a number of papers written by counsel. Reference is made to two of these papers in particular:

"Law of Outer Space—Radio Controls Urgently Needed," [delivered at the Symposium on "Outer Space," October 9, 1958, conducted by the Committee of Aeronautics of the Federal Bar Association of New York, New Jersey, and Connecticut, at the Association of the Bar of the City of New York], and

"The Law of Space—Scientific and Technical Considerations, "New York Law Forum, July 1958.

Copies of these papers are attached as Appendix B. These papers are attached hereto for the purpose of affording the Commission a fuller discussion of the need for controlling and regulating radio frequency use in space.

There is also attached in Appendix B, a bibliography of counsel's various other writings on astronautics in general and the use of radio frequencies therein. The bibliography is offered as a reference source as to the overall extent of activity in space projects, and the important role of radio in the space age.

* * *

Regarding the following comments, the Commission's proposal for frequency allocations has been considered in the light of known present needs for frequencies in space applications. And some consideration has been given to the foreseeable needs for other forms of radio transmission in space projects.

1. Specific areas of the spectrum

The individuals consulted by counsel were unanimous that the Commission's proposals for frequency allocations to the "space radio" services are most seriously inadequate. Dr. Pickering [13] states emphatically that "The frequency allocation proposed is not adequate for the presently planned space program."

Dr. Richard W. Porter [14] notes a "serious gap in region between 150 and 1700 megacycles. Regard as region most important for space communication during next five to ten years in view of present technology."

Dr. Wernher von Braun [15] has commented on the lack of frequency allocations in the range 200–300 mc, and in several other important parts of the spec-

[13] Director, Jet Propulsion Laboratory, California Institute of Technology.
[14] Consultant, Communication and Control, Engineering Services, General Electric Company.
[15] Director, Development Operation Division, Army Ballistic Missile Agency.

trum. Others have commented on the need for allocations in numerous areas of the spectrum.

In fact, several persons consulted by counsel professed surprise and concern that frequency bands which are now actively used in the space program have been omitted from the proposed table of frequency allocations. Mr. Middlebrooks, for example, states:

"I am surprised that the band between 250 and 1000 mc. has been omitted from the proposed 'space' allocations. I am of the opinion that this band could provide at least for the present time the bulk of "space" allocations. This opinion is based on the current state of transmitter and tube development and propagation characteristics."

The panel reviewed in detail the comments of some seventeen individuals on the lack of adequate frequency allocations. The panel is deeply concerned over the paucity of recommended spectrum space and maintains that frequencies in the following areas must be allocated to the indicated 'space radio' services:

The 1 to 2 mc. area

Mr. Seddon recommends that the frequency band 1.3 to 1.5 mc. be allocated to the Space Service. The frequencies in this band would not be used in the Earth/Space service. Mr. Seddon points to a need for this particular band only in regions beyond the atmosphere—specifically 800 miles or more above the earth's surface.

Mr. Seddon states that in the 1.3 to 1.5 mc. band terrestrial absorption is extremely high, so that any signal in this frequency range could not be picked up on the earth. He states further:

"Theoretically, the higher frequency could be pushed up to f_0F_2–0.7 mc. where f_0F_2 is the minimum F_2 critical frequency to any point on earth. At the present time f_0F_2 would be greater than 3.5 mc., but this will decrease in 5 years to nearly 2 mc., especially in the polar regions during magnetic storms. Thus possible future interference in polar regions would limit the top frequency. 1.5 mc. should be safe anywhere, however."

Mr. Dempsey also supports the use of a frequency in this range for the Space Service. He urges that it be located in a part of the spectrum in which "the ionospheric shield will protect the earth services from interference".

The panel agrees with these recommendations, especially since it is contemplated that the use of frequencies in the Space Service would occur under conditions which would preclude interference to radio reception and transmission on earth. Accordingly, it is proposed that the frequency band 1.3 to 1.5 mc be allocated to the Space Service.

The 25.6 to 25.65 mc Area

The persons consulted by counsel agreed generally that the Commission's proposal for a 50 kc. band between 25.6 and 25.65 mc. for the Earth/Space Service is satisfactory for elementary use of radio in space. In the long run, however, the narrow band width will be inadequate for all uses planned for this frequency range.

Mr. Middlebrooks, for instance, expresses doubt as to the adequacy of this 50 kc. band for the amount of use ultimately contemplated by space projects. He has commented that when it later becomes necessary to enlarge the band, extreme displacement of existing services could result, especially in the 26.11–26.47 mc. area which is widely used for base and mobile remote pickup broadcast stations. Mr. Middlebrooks suggests the allocation of space in the 30 to 42 mc. area for further use by the Earth/Space Service.

The 30–42 mc. Area

In addition to the comment of Mr. Middlebrooks, proposals were received by counsel from Dr. Bailey, Dr. Shapley, Mr. Warren W. Berning,[16] and Mr. Russell Pope.[17] They urge that frequencies in this part of the spectrum be allocated to the Earth/Space Service. Mr. Berning and Mr. Pope point out that there is a need for approximately 50 kc. space for communication services in the area around 35 to 50 mc.

Dr. Bailey and Dr. Shapley propose that at least two frequencies about 1 mc. apart be allocated for use in experiments as to the effect of the ionosphere on radio propagation.

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[16] U.S. Army Ordnance, Ballistic Research Division.

[17] Technical Director of Engineering, Golden Empire Broadcasting Co. (Stations KHSL, KHSL–TV, and KVCV).

The International Radio Consultative Committee (CCIR) has recently given attention to the matter of ionospheric experiments involving space flight. Reference is made specifically to Questions Nos. 168(V) and 169(VI) adopted as a result of recent meetings of the CCIR. These questions read as follows:

"QUESTION No. 168(V)

"PROTECTION OF FREQUENCIES USED BY ARTIFICIAL EARTH SATELLITES OR OTHER SPACE VEHICLES FOR COMMUNICATION AND POSITIONAL OBSERVATION

"The C.C.I.R.,
"Considering:
"(a) that transmission of radio signals between the earth and artificial satellites in extraterrestrial positions in space is now an established fact;
"(b) that such extraterrestrial objects may well be consecutively above different countries of the world, thus necessitating international collaboration;
"(c) that radiocommunication between extraterrestrial objects and the earth will be of importance;
"(d) that no provision for such communications was made in the Atlantic City frequency allocation tables;
"DECIDES *that the following question should be studied*:
"1. what frequencies are specially suitable for penetration of the lower layers of the earth's atmosphere?
"2. what are the influences on these frequencies of the meteorological conditions which are dependent on the hour of the day, the season, and the geographical location?
"3 what changes in propagation, for example, in direction, can be expected by the penetration of the troposphere?
"4. what, if any, will be the differences in propagation between ingoing and outgoing signals relative to the earth?

"QUESTION No. 169(VI)

"PROTECTION OF FREQUENCIES USED BY ARTIFICIAL EARTH SATELLITES OR OTHER SPACE VEHICLES FOR COMMUNICATION AND POSITIONAL OBSERVATION

"The C.C.I.R.,
"Considering:
"(a) that communication between the earth and artificial earth satellites is now a practical reality;
"(b) that, while VHF and UHF emissions are likely to be used for many such communication purposes, the ionosphere, nevertheless, will have some influence on the character of the received signals and on apparent positions as observed by radio methods;
"(c) that the study of the effects of the ionosphere on such communications may be facilitated by comparison of HF signals with VHF or UHF signals since the ionospheric effects are larger on the lower frequencies;
"(d) that, in particular, the ionosphere above the F2-layer peak, which cannot normally be studied with radio waves of terrestrial origin, will have some influence on such communications;
"(e) that there is no provision for communications of this kind in the table of frequency allocations of the Atlantic City Conference;
"DECIDES that the following question should be studied:
"1. what are the optimum frequency bands for intercommunication between any two points in space, with particular reference to the earth and to rockets, satellites and space vehicles launched therefrom?
"2. what special practicable measures can be taken in particular in the HF and the lower part of the VHF band to provide protection from interference to signals passing to or from artificial earth satellites or other arising from satellite signals?"

Both the ionospheric propagation experiments and the essential communications described above could be conducted in the same frequency areas, and the Society has previously proposed the frequency 37 mc. for ionospheric propagation experiments [See Comments as to The Fifth Notice of Inquiry, Docket No. 12263, filed May 15, 1958]. It is recommended, therefore, that frequencies in the neighborhood of 37.00 and 38.00 mc. be allocated (for the purposes described above) to the Earth/Space Service.

The 100–150 mc. Area

The Commission recognizes the necessity of allocating frequencies in the 100–150 mc. band, but no specific allocations were proposed. The Commission stated in the Sixteenth Notice that consideration is being given to meeting the "stated requirement [of space radio] for frequency accommodations between 100 and 150 mc. * * * in frequency bands presently allocated exclusively to Government services in that portion of the spectrum."

The 100–150 mc. band is of particular concern to those working in "space radio" because a great deal of the radio equipment used in present space projects has been developed for operation in this part of the spectrum. The Vanguard and Explorer satellites, for example, use frequencies in this band for vital purposes. The same is true with respect to several major missile programs.

Furthermore, there are extensive plans for continued use and development in that band of radio systems for space projects. As was pointed out in the Society's Comments on the Fifth Notice of Inquiry, the United States regards the 100–150 mc. area as particularly well suited for transmissions from earth encircling satellites. It is estimated that as many as 50 of these vehicles will be placed in orbit around the earth during the next year.

Counsel has received expressions of grave concern as to the possible dislocation of existing broadcasting and nonbroadcast services in this region if there is encroachment on the nongovernmental allocations in the 100–150 mc. band.

The interests of the broadcasting industry and the other nongovernmental users in the 100–150 mc. band require careful attention. The present use of 108.00 and 108.03 mc. in the Vanguard program and 107.94 and 107.97 mc. in the Atlas program poses a threat to the FM broadcast industry, as is pointed out by Mr. Middlebrooks.[18] Furthermore, Mr. Adair has commented on the severe crowding among nonbroadcast, nongovernmental users in the band. Numerous common carrier and mobile radio service use frequencies in this part of the spectrum. The Commission has been required to resort to "channel splitting" in order to alleviate intolerable crowding, but even this device has not alleviated the great problems of frequency scarcity.

Turning now to specific frequencies available in the 100 mc. to 150 mc. band, it has been urged by Peter K. Onnigian[19] that a minimum of two 50 mc. bands be reserved for Space and Earth/Space Services. Mr. Onnigian is an active participant in the IGY Earth Satellite program, as the holder of a U.S. Navy contract for a Minitrack backup station. [He is also an experienced broadcast engineer.] Dr. John P. Hagen[20] and Mr. John T. Mengel[21] propose that the temporary use of the frequencies 108.00 and 108.03 mc. be continued, and the Society calls attention to the fact that continued operation on those frequencies probably will be required until firm, suitable allocations are established elsewhere in the 100 to 150 mc. region.

In its Comments on the Fifth Notice of Inquiry the Society urged the allocation of the 148.0–150.8 mc. band for the space radio services. It is considered most essential to reaffirm this proposal, and to add that additional space should be allocated from governmental frequencies, if at all possible.

Accordingly, the panel urges that the frequencies selected by the Commission in the 100 to 150 mc. region be taken from those allocated at present to Government services. The proposal for the allocation of 148.0 to 150.8 mc., set out above, is in compliance with this fundamental consideration.

The 150 mc. to 1700 mc. Area

Mr. S. K. Hoffman,[22] and others, have commented adversely on the lack of proposed frequency allocations in the band between 150 mc. and 1700 mc. They

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[18] The panel also received comments on this subject from Mr. Frank K. Spain, chief engineer, television station WTWV; Mr. Frank Marx, Vice President-Engineering, American Broadcasting Company; Mr. George McClanathan, chief Engineer, Television Stations KPHO and KPHO–TV; Mr. W. D'Orr Cozzens, Director of Engineering, The Intermountain Network; and Mr. Karl Troeglen, Technical Director, stations KCMO, KCMO–FM, and KCMO–TV.

[19] Chief Engineer, Station KBET–TV.

[20] Chief, Vanguard Division, Beltsville Space Center, National Aeronautics and Space Administration.

[21] Head, Space Tracking Systems Branch, Beltsville Space Center, National Aeronautics and Space Administration.

[22] Vice President and General Manager, Rocketdyne, A Division of North American Aviation, Inc.

point to the great ratio between frequencies in the 150 and 1700 mc. band. Mr. Hoffman states:

"The more than one to ten spread between the 150 mc. band and the 1700 mc. band may impose some limitation of the application of technique peculiar to the frequencies between these bands."

Mr. W. L. Rogers [23] has advised counsel that "It appears that the Commission left out the use of frequency band in the neighborhood of 960 megacycles. In this frequency range it is useful because most of the existing equipment is built to operate in this frequency range."

Dr. Martin Alperin [24] also points out that the 960 mc. frequency used by the Explorer satellite is not provided for in the Commission's table of proposed allocations.

Dr. von Braun has commented that there must be provision for space and satellite telemetry in the 200–300 mc. region, and tracking requirements exist in the 450–500 mc. band and the 900–1000 mc. band.

Mr. John L. Sloop [25] lists several frequency areas presently used for telemetry and comamnd that are ignored in the Sixteenth Notice. These include:

215–260 mc. for standard telemetry
400–415 mc. for commands
900–1000 mc. for telemetry

Dr. Porter states that space projects "must have at least 10 megacycles band vicinity 400 mc. and also 1000 mc. free from measurable interference at limited number specific points throughout the world and from other services which would be interfered with by earth satellite transmitting at relatively high power."

Dr. Martin Summerfield [26] and Mr. Enoch J. Durbin [27] point to the "tremendous capital investment" for "procuring of telemetering air and ground equipment" in the 215–235 mc. band and the 1435–1535 mc. band. They add:

"Perhaps even more important than the actual expense of money involved in such equipment, is the gigantic research and development effort which has taken place in the last 15 years toward utilizing these particular frequency bands in an efficient manner."

In summary, there now exists a substantial demand for frequency space for both the Space and Earth/Space services in the large band between 150 and 1700 mc. The Commission now proposes no allocations therein to "space radio," but even at present there is widespread use of frequencies in this region in space projects.

The allocation of frequencies in the following bands to the Space and Earth/Space Services is, therefore, requested:

216–220 mc.
225–235 mc.
250–260 mc.
390–400 mc.
410–420 mc.
430–435 mc.
960–970 mc.
1435–1535 mc.

With one exception, the foregoing frequencies are allocated to government services. Thus a minimum amount of disruption of private users would be necessitated.

The 1700 mc. to 10,000 mc. Area

The Commission's proposal to allocate 1700–1725 mc. 1825–1850 mc. 2275–2300 mc. and 8300–8400 mc. to the Space and Earth/Space Services has received partial approval from those who have communicated with counsel. The principal comments received were those of Dr. Pickering who states that 25 mc. band widths in this area will be inadequate, and at least 50 mc. preferably 75 mc. should be allocated for Space and Earth/Space radio services.

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[23] Manager, Azusa Operations, Aerojet-General Corporation.
[24] Western Division, Office of Scientific Research, Air Research and Development Command, USAF.
[25] National Aeronautics and Space Administration, Lewis Flight Propulsion Laboratory.
[26] Professor of Jet Propulsion, Department of Aeronautical Engineering, Princeton University.
[27] Department of Aeronautical Engineering, The James Forrestal Research Center, Princeton University.

Mr. Adair also states that the bandwidths in this area appear to be inadequate. He says that considerable trouble with respect to frequency stability and related problems may arise if the narrow 25 mc. bands proposed by the Commission are retained.

Mr. Dempsey calls for allocations in the 3500–3900 mc. band, the 4400–5000 mc. band and particularly in the lower end of the 5925–8500 mc. band. He states that the "development of masers, galactic noise levels, and atmospheric attenuation characteristics make allocations in these frequency bands necessary to achieve the extreme ranges required for Earth/Space Service." He adds that the "optimium frequency for Earth/Space Service in the foreseeable future probably lies very close to 6000 mc." Mr. Sloop points out that existing telemetry and command frequencies in the 2800–3000 mc. and 5400–5600 mc. bands should be provided for in the new frequency allocation tables.

The panel, after considering all of these proposals, agreed that the proposal of Dr. Pickering and Mr. Adair for wider bandwidths in the frequency areas mentioned in the Commission's proposal is essential. The panel also urged that consideration be given to the proposals of Mr. Dempsey and Mr. Sloop for additional frequency space in these bands:

2800–3000 mc.
3500–3900 mc.
4400–5000 mc.
5400–5600 mc.
5925–8500 mc.

Inasmuch as complex problems involving both governmental and nongovernmental allocations are raised in connection with the foregoing frequency bands, the Society points out herein that specific frequency allocations for radio services in those regions may involve frequency sharing and other devices for protection of existing users.

The Area Above 10,000 mc

The Commission proposes to allocate the bands 15,150–15,250 mc and 31,500–31,800 mc to the Space and Earth/Space Services. A few comments were received as to these parts of the Commission's proposal, and with respect to the use of any other frequencies greater than 10,000 mc. Clure H. Owen [28] suggests that band widths in the order of 1,000 mc be allocated in the two areas mentioned. He states:

"As I visualize a glimpse into the future it may be possible that there will be several space stations in simultaneous operation and it may be necessary to transmit wideband or high speed transmission in response to interrogators. Accordingly, the actual amount of spectrum space would be a wild guess at best. However, as the two upper bands are at the present time relatively unused, they might be considered experimental. I would suggest that each of these bands have a width of 1,000 mc."

The use of band widths in the order of 1,000 mc was proposed by the Society in its Comments on the Fifth Notice of Inquiry in Docket No. 12263, and such proposals were based upon the recommendation of an earlier panel of scientists and engineers who had assisted the Society. Inasmuch as the spectrum above 10,000 mc is uncrowded and unused in large measure, the allocation of 1,000 mc bands in the 15,150 mc and 31,500 mc region is considered wholly practical and highly desirable.

Mr. Hoffman offered the following comment as to the use of frequencies greater than 10,000 mc:

"Allocations Number 231F and 231G will be subject to possible restrictions in the Earth to Space service caused by excessive attenuation of signals due to the absorption phenomenon in the atmosphere and possible water vapor. Because space to space service would not be affected by this absorption it might be useful to allocate a band of frequencies above the 31,000 mc region; possibly in the 80,000 to 90,000 mc band."

2. Summary

A recapitulation of the frequencies proposed both by the Commission and in this document is attached as Appendix C. The Commission's attention is invited to the table of frequency allocations first proposed by the Society in its Comments on The Fifth Notice of Inquiry. That table is attached to counsel's paper, "Law of Outer Space—Radio Controls Urgently Needed" [a part of Appendix B hereto].

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[28] Administrative Assistant, Engineering, American Broadcasting Company.

III. FREQUENCY RELATION

Dr. von Braun, Dr. Bailey, and Dr. Shapley agree that there should be a definite harmonic relation among the frequencies allocated for Space and Earth/Space services. Mr. Adair points out that the harmonic relation would conduce to the efficient interchange of antennas used in some of the various frequency bands. Dr. von Braun urges such a method of allocation especially as to frequencies in the 200 mc–1,000 mc range.

IV. CONTROL OF TRANSMISSION

It is recognized that this proceeding is concerned only with definitions and allocations, but the Society desires to call attention to the potentially serious problem of controlling unmanned transmitters in space.

Mr. Seddon describes the problem vividly as follows, "if the Vanguard 'grapefruit' had more output power, it could be a nuisance for the next 200 years." He is referring, of course, to the transmitter operating in one of the small Vanguard satellites which has an expected orbital "life" of 200 years. The solar-power source has an equally long anticipated "life."

Mr. Middlebrooks also has expressed concern as to the effects of indefinitely long transmissions, and he suggests that all "space radio" transmitters be equipped with silencing circuits. Mr. Middlebrooks states:

"These frequencies would be capable of remotely 'silencing' any 'space' station which is not directly under the control of humans. By treaty all nations should agree that no 'space' transmitter will be orbited unless it is equipped with silencing circuits. This silencing circuit should be of the 'fail safe' type. In other words the 'space' transmitter can only function as long as the 'space' object is receiving a signal from earth. A system which depends on a receiver located on the 'space' object might fail thereby, allowing the 'space' transmitter to continue to function even though it had served its useful purpose."

Mr. Adair points out that there is a potentially serious problem if a transmitter in space drifts off the planned frequency, and he suggests a "destruct" mechanism and circuit similar to that used to destroy faulty missiles and rockets which pose a threat to life or property.

Therefore, although the matter is not directly germane to this phase of the Inquiry, the Society takes this opportunity to recommend that appropriate regulations be drafted which would require the regulation of transmitters employed in the new "space radio" services which the Commission has proposed.

Any nation sending radio equipment into space (except equipment destined for probes beyond Mars and Venus) must be required to be able to command such radio equipment to stop transmitting—or the equipment may be the source of interfering signals for decades to come. With the improvements in solar batteries and the use of outer orbits where sunlight is constantly available as the power source, radio equipment in satellites may well, in a very short time, be capable of indefinite life, and therefore of indefinite interference, unless controllable.

The Society and its counsel express great appreciation to the Commission and its staff and to the individuals listed in Appendix A hereto for their contributions to the development of the several space radio services.

Respectfully submitted.

AMERICAN ROCKET SOCIETY,
By ANDREW G. HALEY, *General Counsel.*

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Washington 6, D.C.
January 26, 1959.

LAW OF OUTER SPACE—RADIO CONTROLS URGENTLY NEEDED

A paper delivered by Andrew G. Haley at the Symposium on "Outer Space" held on October 9, 1958, by the Committee of Aeronautics of the Federal Bar Association of New York, New Jersey and Connecticut, at the Association of the Bar of the City of New York

SUMMARY

The closer we get to the moon, the farther away individual nations retreat from considering the legal problems of outer space. For example, the Colloquium on Space Law held on August 29, 1958, at The Hague under the auspices of the International Astronautical Federation, the U.S.S.R. sent no spokesman—although urgent invitations had been delivered to U.S.S.R. experts. Even the United States authorities do not seem to believe that the provisions concerning international cooperation contained in the National Aeronautics and Space Act, signed by President Eisenhower in August 1958, cover the legal and social implications of space exploration and travel. This ostrich-like attitude of official chancellories presents a real threat to the security of the human race.

The use of radio in outer space presents one clear example of the blindness of statesmen in not realizing that law must precede both vehicles and man into outer space. The situation is particularly deplorable as the individual problems are completely controllable if handled at this time. For example, the United States has already announced that it will project a satellite mounting cameras and television equipment. The actual national laws of most countries positively forbid such reconnaissance. It is true that the statutes themselves limit the reconnaissance from above a nation in "airspace," but the principle remains the same and there should be a clear understanding achieved with respect to outer space. The nations of the world must immediately adopt international regulations providing for safety of life and property in space, providing for the control of the landing of any satellite and providing for the control of radio transmissions from objects in space. All these matters should have been the subject of international agreement before the first sputnik was projected into outer space.

The means of effecting these controls, from a technical standpoint, are comparatively simple—that is, the satellites should contain mechanisms which would be activated by radio command frequencies. Remember, it takes as much energy to bring a satellite back to Earth as it does to project it into orbit. However, the orbit may be altered by very small applications of thrust, and if altered in the direction of the Earth's atmosphere the consumption of energy will then become a function of atmospheric friction. The main point is that we cannot shoot down a satellite. By shooting a satellite we would only create a worse condition because the object would then become fragmented but nevertheless continue on in orbit. Furthermore, those Sputniks which have returned did not atomize in the atmosphere but descended in sizable chunks. There is no guarantee that these chunks of metal, at present absolutely uncontrolled, will not prove to be a lethal metallic rain right on the Empire State Building or, for that matter, on the Kremlin. We have a Vanguard operating in outerspace using the radio frequency 108 megacycles, whose life expectancy is 200 years, and because it uses solar batteries this object may interfere with a very valuable radio frequency, also for 200 years. We have no means to shut off this squealing detriment to priceless communications.

In a word, the statesmen of the world must awaken to the fact that by ignoring the legal and sociological problems of space exploration they are leaving the door open to social and scientific pandemonium.

Law of Outer Space—Radio Controls Urgently Needed

A paper delivered by Andrew G. Haley[1] at the Symposium on "Outer Space" held on October 9, 1958 by the Committee of Aeronautics of the Federal Bar Association of New York, New Jersey and Connecticut, at the Association of the Bar of the City of New York

It is slowly dawning on the lawyers and statesmen of the world that the reality of space-circling vehicles—Sputniks, Vanguards, and Explorers—is creating legal problems to which no solutions have been advanced. much less thought out to a determination. These problems require the restatement and reassessment of certain fundamental principles of international law, but many of the problems are wholly *sui generis*, and with respect to these we have no background or precedents to guide us. I mean by this that we have no positive precedents, although we do have some excellent landmarks to indicate pitfalls

[1] President of the International Astronautical Federation; General Counsel of the American Rocket Society; Haley, Wollenberg & Kenehan.

which in any event must be avoided in the future if we are to maintain civilization.[2]

At the outset of this paper the author desires to emphasize that in this discussion he actually is not criticizing any nation or administration. The sole purpose in pointing out violations and derogations of laws, treaties and rules and regulations is to emphasize that the natural sciences have far outstripped the social sciences in the achievements of mankind on the way to the conquest of space. Above all, the experts and stewards of the science of jurisprudence—lawyers and politicians—have completely failed up to this time in recognizing the legal problems and in implementing solutions. Specifically, the author is not criticizing the U.S.S.R. for the use by the Sputniks of the standard frequency of 20 megacycles, or the frequency of 40.002 megacycles. The author is fully

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[2] Writings of Andrew G. Haley: International Cooperation in Rocketry and Astronautics, Jet Propulsion, The Journal of the American Rocket Society, New York, New York, Vol. 25, No. 11, November 1955; Space Law—Basic Concepts, presented at the 75th Annual Convention of The Bar Association of Tennessee, Nashville, Tennessee, June 14–16, 1956, Tennessee Law Review, Vol. 24, No. 4, June 1956; Space Law and Metalaw—A Synoptic View, presented at the VIIth Annual Congress of the International Astronautical Federation, Rome, Italy, September 19, 1956, Harvard University Law Record, Cambridge, Massachusetts, Vol. 23, No. 6, November 1, 1956 (also in Proceedings of the VIIth International Astronautical Congress, Associazione Italiana Razzi, Rome, Italy, Sept. 17–22, 1956); Basic Concepts of Space Law, presented at the American Rocket Society 25th Anniversary Annual Meeting, Law Record, Cambridge, Massachusetts, Vol. 23, No. 6, November 1, 1956 (also in Proceedings of the VIIth International Astronautical Congress, Associazione Italiana Razzi, Rome, Italy, Sept. 17–22, 1956); Basic Concepts of Space Law, presented at the American Rocket Society 25th Anniversary Annual Meeting, Chicago, Illinois, November 14–18, 1955, Jet Propulsion, The Journal of the American Rocket Society, Vol. 26, No. 11, November 1956; Droit de l'Espace et "Mêtadroit" (Limites de Jurisdiction), Revue Generale de l'Air, 1957, Paris; Seventh International Astronautical Federation Congress Stresses Cooperation, Jet Propulsion, The Journal of the American Rocket Society, New York, New York, Vol. 27, No. 1, January 1957; Weltraumrecht und Recht Ausserhalb der Erde, Zeitschrift für Luftrecht, Institute für Luftrecht der Universitat Köln, Germany, Issue 2, 1957, Carl Heymanns Verlag KG, Köln, Germany; International Situation and Legal Involvements with Respect to Long-Range Missiles and Earth-Circling Objects, February 1957, U.S. Air Force Office of Scientific Research, Washington, D.C., Pergamon Press, Ltd., London, England; The Present Day Developments in Space Law and the Beginnings of Metalaw, presented at the American Rocket Society No. 2, February 7, 1957; Space Law—Basic Concepts, Law Review Digest, Kimball-Clark Publishing Co., Boonton, New Jersey, Vol. 7, No. 3, March–April 1957, Digest of article published in the Tennessee Law Review, Fall 1956, Vol. 24, No. 5, pp. 643–657; The Present Day Developments in Space Law, The Canadian Oil Journal, Edmonton, Alberta, Canada, Vol. 8, No. 7, March 1957, Vol. 8, No. 8, April 1957, Vol. 8, No. 9, May 1957; Waltraumrecht und Recht Ausserhalb der Erde, Weltraumfahrt, Zeitschrift für Astronautik und Raketentechnik, Frankfurt/Main, Germany, April 1957; Space Law and Metalaw—Jurisdiction Defined (Revised), paper read before the Deutsche Gesellschaft für Raketentechnik und Raumfahrt, at the Technical University of Stuttgart, April 13, 1957; Space Law and Metalaw—Jurisdiction Defined, presented at the American Rocket Society Spring Meeting, Washington, D.C., April 3–6, 1957, Journal of Air Law and Commerce, Northwestern University, Evanston, Illinois, Vol. 24, No. 3, Summer 1957; The International Scene [foreign astronautical publications], Astronautics, American Rocket Society, New York, New York, Vol. 2, No. 2, September 1957; The International Scene [German activity in rocketry], Astronautics, Vol. 2, No. 3, October 1957; Space Law—The Development of Jurisdictional Concepts, presented at the VIIIth Annual Congress of the International Astronautical Federation, Barcelona, Spain, October 6–12, 1957 (also in German); The International Astronautical Federation, Federal Bar Journal, Washington, D.C., October–December 1957, pp. 470–474; Law Must Precede Man Into Space, Missiles and Rockets, American Aviation Publications, Washington, D.C., Vol. 2, No. 11, November 1957; Law and Economics of the Age of Space, presented on lecture tour of U.S. universities, November 1957; The International Scene [Suite 304, The Ritz, Barcelona], Astronautics, Vol. 2, No. 5, December 1957; The Russian Satellite—Legal and Economic Problems, presented at the American Rocket Society 12th Annual Meeting, New York, New York, December 4, 1957; Can Russia Claim the Moon?, American Weekly, New York, New York, January 15, 1958; The Law of the Space Age—Spiritual, Economic, and Scientific Foundations, presented at the Evangelical Academy, Loccum, Germany, February 28, 1958; The International Scene [preparation of papers for the IXth Annual Congress of the IAF], Astronautics, Vol. 3, No. 2, February 1958; The Commercial Implications of Missiles, Satellites, Space Age, address before the American Management Association, New York, New York, February 21, 1958, Commercial and Financial Chronicle, New York, New York, March 13, 1958; International Cooperation in Astronautics, Foreign Service Journal, Washington, D.C., April 1958, pp. 42–50; Astronautics and Space Exploration, testimony before the Select Committee on Astronautics and Space Exploration, U.S. House of Representatives, May 8, 1958; Der Mensch Stösst in den Himmelsraum, New York Staats-Zeitung und Herold, Woodside, N.Y., May 1, 2, 3, 5, 6, 7, 8, 1958 (excerpt, in German, from paper given at Loccum Academy, Loccum, Germany, February 28, 1958; The Law of Outer Space—Scientific and Anthropocentric Considerations, presented at the University of Moscow, Moscow, U.S.S.R., May 29, 1958; The International Scene [the law of outer space, international cooperation in astronautics, formation of new astronautical societies—in and out of Eastern Europe—subjects of long journey—Part I], Astronautics, Vol. 3, No. 5, May 1958; Law of Outer Space—A Problem for International Agreement, American University Law Review, Washington, D.C., Vol. 7, No. 2, June 1958; The International Scene [subjects of long journey—Part II], Astronautics, Vol. 3, No. 6, June 1958; Space Vehicle Torts, University of Detroit Law Journal, Detroit, Michigan, Fall 1958.

aware that nations other than the U.S.S.R. have come to the conclusion that frequencies in the range of the standard frequency follows. Above all, this paper is not a propaganda statement for any nation or against any nation, and it must be considered exactly on the merits—namely, that order must emerge from the chaos now existing with respect to the world-wide allocation of radio spectrum for astronautical use.

Some of these problems are concerned with jurisdiction; sovereignty; launching and landing privileges; torts in all aspects; instrumentation rights, privileges, and restrictions in the vehicle itself; and so on. An immediate problem—one indeed that has existed since the launching of the first Sputnik on October 4, 1957,[3] is the control and regulation of the use of the radio spectrum for space purposes. The author will address himself to the problem last stated.

As is pointed out *supra*, the first overt or actual violation of the rules and regulations promulgated pursuant to international treaties, was occasioned by the U.S.S.R.'s use of the frequencies of 20.005 and 40.002 megacycles.[4]

The frequency 20.005 megacycles is in the center of the frequency band 19.990–20.010 megacycles which the International Telecommunication Union has assigned as the Standard Frequency Service.[5] Stations employing frequencies in this band conduct "a radiocommunication service for the transmission of standard and specified frequencies of known high accuracy, intended for general reception."[6]

In fact, 20.005 megacycles is the exact frequency assigned to Station PEN at Kootwijk, The Netherlands.[7] The experimental station of the United States National Bureau of Standards, Station WWV in Lanham, Maryland, has the assigned frequency of 20.0 megacycles. The ITU has assigned a guard band of 10 kilocycles on each side of this frequency to prevent interference with Station WWV's operations. The signals of the Soviet satellites at 20.005 megacycles were 5 kilocycles within this zone of interdiction.

Furthermore, the signals on the frequency of 40.002 megacycles also were in an actively used frequency band. In Region 1 (Europe, Soviet Asia, and Africa), and Region 2 (the Western Hemisphere) the frequency 40.002 megacycles is allocated to fixed and mobile radio communication services. In Region 3 (Asia and Oceania) aeronautical radionavigation services are assigned this frequency. The frequency 40.0 megacycles just 2 kilocycles away from the frequency used by the Soviet satellites, is the assigned frequency of radio stations on the Isle of Guernsey and in Guanabocoa, Cuba. Being in the upper range of the fixed and mobile services band, the signal at 40.002 megacycles is less than one megacycle below the frequency assigned for broadcasting purposes in Region 1. A broadcasting station in Brocken, Germany, operates on an assigned frequency of 41.0 megacycles.

The International Telecommunication Convention and the Radio Regulations adopted pursuant thereto[8] clearly show that the use by the U.S.S.R. of 20.005 and 40.002 megacycles per second [wave lengths of about 15 and 7.5 meters, respectively] is contrary to international law. There can be no doubt as to the use of these frequencies by the satellites 1957 Alpha, 1957 Beta and 1958 Delta, as the actual frequencies have been frankly designated in official publications of the U.S.S.R. and literally thousands of readings on the frequencies have been made at points throughout the world.[9] On no occasion did the U.S.S.R. apply to the appropriate agencies of the International Telecommunication Union at Geneva for permission to use the frequencies 20.005 and 40.002 megacycles, and indeed the appropriate agencies of the International Telecommunication Union were not officially notified of the use of these frequencies by the Sputniks. In this connection it must be kept in mind that the U.S.S.R. is a signatory member of the International Telecommunication Union and has been one of the most active nations participating in the work of the International Telecommunication Union.

It must be kept in mind that technically the U.S.S.R. may actually be violating no treaty or rule or regulation when the earth-circling vehicle is in outer space

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[3] TASS dispatch, October 4, 1957.
[4] Id.
[5] ITU Radio Regulations, Chapter III, art. 5, p. 42–E.
[6] *Ibid.*, Chapter I, art. 1, p. 4–E.
[7] Liste des Fréquences, Bureau of the International Telecommunication Union, Bern, 1947.
[8] International Telecommunication Convention—Final Protocol to the Convention; Additional Protocols to the Convention; Resolutions, Recommendations, and Opinions, Geneva.
[9] Pravda, October 5, 1957; Pravda, October 9, 1957; Radio No. 7, July 1957, pp. 17–23 and No. 8, August 1957, pp. 17–20.

beyond the vertical area of "airspace", as the nations of the world claim jurisdiction only through "airspace", and not in outer space. As no international arrangement has been made with respect to outer space, it may very well be argued that existing treaties do not extend to outer space and that the dissemination of radio signals from vehicles in outer space has not been covered by any law, treaty or rule or regulation.[10] However, when the earth-circling vehicles are operating within "airspace" and are using unauthorized frequencies, they are certainly violating laws, treaties and rules and regulations—common to all nations of the world. It is to this latter problem that this paper is addressed. As we are not specifically and exclusively discussing jurisdiction in outer space, or sovereignty, the intricate questions involved in those aspects of the problem will not be treated herein further, and existing law will be considered arbitrarily without regard to outer space jurisdiction.

Article 3 of the International Telecommunication Convention provides in Paragraph 2(a) that the purposes of the Union created by the Convention shall be in particular to "effect allocation of the radio frequency spectrum and registration of radio frequency assignments in order to avoid harmful interference between radio stations of different countries."

Article 44 of the same Convention provides:

"1. All stations, whatever their purpose, must be established and operated in such a manner as not to result in harmful interference to the radio services or communications of other Members or Associate Members or of recognized private operating agencies, or of other duly authorized operating agencies which carry on radio service, and which operate in accordance with the provisions of the Radio Regulations.

"2. Each Member or Associate Member undertakes to require the private operating agencies which it recognizes and the other operating agencies duly authorized for this purpose, to observe the provisions of the preceding paragraph.

"3. Further, the Members and Associate Members recognize the desirability of taking all practicable steps to prevent the operation of electrical apparatus and installations of all kinds from causing harmful interference to the radio services or communications mentioned in paragraph 1 of this Article."

In Chapter III, Article 5, of the Radio Regulations annexed to the Convention, it is provided that the worldwide standard frequency shall be the channel 19.990–20.010 megacycles. The seriousness of this assignment may be understood from the fact that on this channel time signals are broadcast and the time signals are monitored throughout the world. For example, in the United States, Station WWV, Washington, D.C., transmits the official time signals and constant checks on these time signals are made at various points, such as the Bureau of Standards radio reception center in Boulder, Colorado. This reception has actually been interfered with by the Sputniks. Furthermore, the Bureau of Standards maintains chains of recording stations for radio noise measurement in areas throughout the world and these stations operate on the quiet part of the guard band of the standard channel of 20 megacycles. These stations also have been interfered with by the Sputniks. It is true that the period of interference has not been great, but if the United States follows the lead of the U.S.S.R. in derogating the standard frequency, and if the combined number of earth-circling satellites should aggregate as many as 60—which the United States and the U.S.S.R. have publicly projected—then interference would become serious indeed.

It must be remembered that the standard frequency of 20 megacycles is allocated for worldwide use and the experience of the United States is being discussed on a merely illustrative basis—as every nation would be affected, but we do not have time or space to discuss the experience of every nation.

Article 3 of Chapter III of the Radio Regulations aforesaid reads as follows:

"1. The countries, members of the Union, adhering to these Regulations, agree that in assigning frequencies to stations which, by their very nature, are capable of causing harmful interference to the services rendered by the stations of another country, they will make such assignments in accordance with the table of frequency allocations and other provisions of this chapter.

"2. The frequencies so assigned shall be selected in such a manner as to avoid causing harmful interference with services carried on by stations using frequencies assigned to them in conformity with the provisions of this chapter and which are entitled to international protection from harmful interference as provided in article 11."

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[10] Supra, note 1; see also Hanover, Air Law and Space, Göettinger (1953); Meyer, comment in Proceedings of the American Society of International Law (1956).

The foregoing states the basic policy agreed to by all the nations—a policy which was not adhered to by the U.S.S.R. It must also be remembered that the U.S.S.R. did not notify the International Frequency Registration Board at Geneva. Station WWV and the recording stations, as well as other stations throughout the world, on the other hand, have notified their operation on the standard frequency for many years.

Article 2 of Chapter IV of the Radio Regulations aforesaid reads in part:

"(2) Any frequency assignment which is in full conformity with all provisions of the Radio Regulations shall be recorded in the Registration Column.

"Such a frequency assignment shall have the right to international protection from harmful interference.

"(3) Any frequency assignment which, in any measure, contravenes the provisions of the Radio Regulations, but on the use of which the notifying country insists, shall be recorded in the Notification Column."

This Article also provides:

"§ 2. (1) In order to obtain international recognition of a frequency assignment, each country, upon the assignment by it of a frequency to a fixed, land, broadcasting, radionavigation land, or standard frequency station within its jurisdiction or control, or upon changing an existing frequency assignment or any of the particulars (specifically set forth in 318), shall notify the Board by any means of suitable record communication."

I believe that the illustration of the need for conformity to law, international treaty obligations and rules and regulations is sufficiently covered by the misuse of the standard frequency aforesaid, and that it will not be necessary to pursue the facts concerning the unlawful use of the frequency 40.002 megacycles. The point will not be labored further.

The lawyers of the world have further demonstrated their lack of social consciousness and their lack of understanding of the meaning of the conquest of space—even in the limited form of the earth-circling vehicles—by their failure to even suggest the existence of other vital problems which are not covered by existing law, treaty or rule or regulation.

No intelligent reader of the daily press can help but recognize that the projection into orbit of vehicles equipped with solar batteries, radio transmitting apparatus and an orbital life of from a few months to a few centuries will present problems of extreme concern to all the nations of the world.

With respect to the three Sputniks, we witnessed the destruction of two and we know that the life period of the third will not be long. In the case of the 1957 Alpha, we know that with the final phase of the reentry the rocket disintegrated into elements of different drag coefficients, whose impacts were strewn over an arc the length of the satellite trajectory. It must be assumed that the final pass of any earth-circling vehicle will not result in a harmless vaporization of the metal components, but as the vehicles grow larger and larger the metal scattered in the death plunge will become more and more dangerous to human life and property.

We must therefore provide, through the means of radio command, that the nation which projects a satellite will be able to guide that satellite to earth in an area free from threat to human life and property. I have seen no reference to this vital problem in any of the writings of the natural or social scientists. I have, however, seen many statements by politicians, scientists and even lawyers in which positive plans for manned space flight and space exploration are announced—and I refer to such great world leaders as President Eisenhower and Prime Minister Khrushchev.

Yet no one seems to realize the terrible implications of placing earth-circling vehicles in orbit without first providing means to control these vehicles. American officials have stated that at least 30 earth-circling vehicles are proposed, and the Russians have estimated at least that number. In the near future these Sputniks will achieve higher and more enduring orbits. They will be equipped with solar batteries and radio transmitters which will be activated and able to transmit probably for hundreds of years. But none has even suggested the necessity for laws, treaties, rules and regulations to control these behemoths of space—objects which could well constitute peril to safety of life and property in space which could not be controlled.

Even scientists seem to forget that it takes as much energy to divert a space vehicle from its orbit back to earth, as it does to project the vehicle into orbit. So we have the chaotic situation where lawyers may consider space laws on some pink cloud in their imaginations, while completely forgetting the practicalities of vital problems which face civilization in the age of space.

In this discussion the author has briefly touched upon two very apparent and essentially simple problems—namely, (1) the absolute necessity to control the placement of the re-entering space vehicle in order to protect human life and property, and (2) the necessity to be able to rid outer space of objects in order to provide for safety of life and property in future space navigation.

A third and less important requirement is the control of the radio transmitter on the earth-circling vehicle. At the present time radio engineers throughout the world are possessed of the unpleasant knowledge that for indeterminate periods the frequencies of 20.005, 40.002 and 108.00 megacycles are in a sense usurped for Sputnik, Vanguard and Explorer operation to the possible detriment of assigned frequency usage. One must understand that the radio spectrum is very limited and that the frequencies involved are extremely valuable and they may be quite essential to some other services. To tie them up in this fashion requires international discussion. Accordingly, there must also exist a radio command which will silence these earth-circling vehicle radio transmitters.

Years ago the author recognized these problems and since then has endeavored to alert the world to the need for constructive solutions. In particular the author has attempted to convince the International Telecommunication Union in Geneva of the necessity for special allocations of frequencies for space uses.

Also, an effort has been made to provide the technical basis upon which any such allocation must be based. Agencies of the ITU, the International Consultative Committee on International Radio, has the task of studying the scientific and technical problems connected with radio communications. The investigation of such phenomena as ionospheric and tropospheric effects on wave propagation is the special province of the CCIR. This Committee does not allocate frequencies—it has the duty "to study technical radio questions and operating questions the solution of which depends principally on considerations of a technical radio character and to issue recommendations on them."[11] The actual frequencies finally selected are notified to the International Frequency Registration Board, Geneva.[12]

It is believed that the CCIR has a basic duty to civilization to study the problems and needs of extra-terrestrial communications. In view of the importance of the CCIR to the astronautics program, the author traveled to Warsaw to attend the CCIR conference in that city during August 1956, to present the views of the International Astronautical Federation, which were assembled from the scientists of several countries. He proposed that the CCIR undertake a review of the requirements of astronautical radio frequencies and promised the cooperation of the IAF in this endeavor. The minutes of the Thirteenth Plenary Meeting of the CCIR reveal that the petition of the IAF was considered by the Committee's Director, Professor van der Pol. The result was that the IAF was advised to seek consultative membership in the ITU, and the hope was expressed that "collaboration with [the IAF] would give excellent results."[13] The CCIR did not agree to undertake studies at that time.

Pursuant to the advice of Professor van der Pol, on May 10, 1957, the IAF made appropriate application to the then Secretary-General of the ITU, Marco Aurelio Andrada. The ITU granted the IAF full nongovernmental consultative status. In all fairness it must be said that Secretary-General Andrada (since deceased); Acting Secretary-General Gerald C. Gross; and Dr. E. Metzler, Director of the CCIR, have shown the IAF, and, in a broader sense, those who represent the cause of astronautics, every consideration. This cooperative approach resulted in the following progress in the efforts to bring order into astronautical radio:

A meeting of Study Group XI of the CCIR was scheduled to be held in Moscow from May 28–June 10, 1958. The author was advised of this meeting and he received a visa from the USSR to attend the meeting. Study Group XI is chiefly concerned with various aspects of television systems, television standards, and requirements for the transmission of television over long distances. The author had in mind the statements of President Eisenhower,[14] members of the USSR Academy of Sciences, such that of V. Petrov,[15] and the writings of numerous scientists throughout the world, such as the writings of John R. Pierce, Director of Research, Electrical Communications, Bell Telephone Laboratories.[16] These

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[11] International Telecommunication Convention, Atlantic City, 1947, Article 8, p. 9–E.
[12] International Telecommunication Convention, Atlantic City, 1947, Article 6, p. 7–E.
[13] Minutes of the Thirteenth Plenary Meeting of the CCIR, Warsaw (1956), p. 10.
[14] Press release, White House, Washington, D. C., March 26, 1958.
[15] RADIO, June 1956.
[16] See in particular, Orbital Radio Relays, in Proposal of the American Rocket Society to the National Science Foundation, November 1954.

declarations and writings, in positive terms, propose the use of satellites as passive and active television relay stations, and as television originating bases for the dissemination to earth from outer space of scientific data. At the twelve-day meeting of the CCIR Study Group XI in Moscow it was decided that the questions, problems, and study proposals which were submitted by the author to the Plenary Session could better be acted upon by Study Groups V and VI, and the Director of the CCIR proposed the following program, which, of course, must be approved at the next meeting of the CCIR:

"*considering*

"(a) the rapid development of rockets in general and of artificial satellites in particular;

"(b) that transmission of radio signals between the earth and extraterrestrial positions in space is now an established fact;

"(c) the use of satellites as measuring and observation stations and possibly as relay stations;

"(d) that extraterrestrial objects may well be consecutively above different countries of the world, thus necessitating international collaboration;

"(e) that radiocommunication between extraterrestrial objects and the earth will be of utmost importance;

"*decides* that the following question should be studied:

"1. what frequencies are specially suitable for penetration of the layers of the earth's atmosphere;

"2. what are the influences on these frequencies of the hour of the day, the season, the geographical location and solar activity;

"3. what deviations in propagation direction can be expected by the penetration of the ionosphere;

"4. what, if any, will be the differences in propagation between ingoing and outgoing signals relative to the earth:

"5. are special phenomena to be expected that do not occur in transmission between two points on earth;

"6. what is the possible influence of the troposphere on wave propagation to and from extraterrestrial objects?"

In addition to the foregoing, the United States Preparatory Committee—International Radio Conference, which is considering the program of CCIR Study Group VI in anticipation of the Ninth Plenary Assembly of the CCIR to be held in Los Angeles in April 1959, has circulated a proposal based upon findings that "observation of radio emissions of the first earth satellite have already yielded valuable information about the ionosphere, as well as about problems of space travel," and the Committee recommends that "clear channels be set aside for the use of satellite and space ship emissions." These observations and recommendations were timely, as they were available for consideration by CCIR Study Group VI in its Geneva meeting during August 1958. The author attended, acting as Observer at that meeting, as President of the IAF. Final decisions will be reached at the Plenary Session in Los Angeles in 1959.

There is certainly hope for comparatively expeditious action looking toward the allocation of spectrum space for astronautical radio, as a Plenary Convention will be held during July 1959 in Geneva. This Convention will have complete power to revise the Atlantic City Convention, 1947, and, indeed, if necessary, to enter into a completely new Convention. It is heartening to observe that most nations have recognized the basic necesisty of providing spectrum space for astronautical radio.

On many occasions and in many official ways the United States has recognized the necessity of providing spectrum space and of achieving international cooperation to utilize astronautical radio and to prevent interference.

The author, as General Counsel of the American Rocket Society, has entered appearances, pleadings and scientific astronautical reports and comments in proceedings instituted by the Federal Communications Commission looking toward reallocations and new allocations of radio frequencies to the various services, including astronautical radio.

The author is also serving on Committees of the United States State Department Preparatory Committee—International Radio Conference.

Similar preparatory groups and committees have been established in nations throughout the world.

Final observations are most pertinent and necessary:

(1) Most of the nations of the world must change their domestic laws and rules and regulations relating to radio, to accommodate the concepts, requirements, and problems of astronautical radio. Certainly in the not distant future

the United States must amend its Communications Act of 1934 to embody new provisions relating to astronautical radio.

(2) Fortunately, the international problem may be handled through the very efficient agency, the International Telecommunication Union, which is composed of more adhering nations than practically any other international organization. The ITU has had an excellent record of achievement and has certainly taken more action in connection with astronautical problems that any other international body.

The author again desires to emphasize that the views expressed herein are those of a lawyer—not a politician—and that he is critical of no nation, and this is not a propaganda document in favor of or in opposition to any nation. This paper simply embodies a plea for international cooperation in providing radio facilities for astronautical purposes—an objective which is essential to the orderly progress of civilization and peaceful interrelations among nations.

The lawyer and the scientist may be interested in the program the author submitted to the United States Department of State, which is here quoted in its entirety:

INTERNATIONAL ASTRONAUTICAL FEDERATION

(Original language: English)

The International Astronautical Federation proposes the C.C.I.R. study astronautical communications services. On behalf of the Federation, Mr. Andrew G. Haley has discussed the use of frequencies by space-circling vehicles as well as the future of the service, and is available to expand on the needs of this new service as well as the problems involved.

At the 12-day meeting of the C.C.I.R. Study Group XI in Moscow it was decided that the questions, problems, and study proposals which were submitted by the author to the Plenary Session could better be acted upon by Study Groups V and VI, and the Director of the C.C.I.R. proposed the following program, which, of course, must be studied by the C.C.I.R.:

"*considering*

a) the rapid development of rockets in general and of artificial satellites in particular;

b) that transmission of radio signals between the earth and extraterrestrial positions in space is now an established fact;

c) the use of satellites as measuring and observation stations and possibly as relay stations;

d) that extraterrestrial objects may well be consecutively above different countries of the world, thus necessitating international collaboration;

e) that radiocommunication between extraterrestrial objects and the earth will be of utmost importance;

"*decides* that the following question should be studied:

1. what frequencies are specially suitable for penetration of the layers of the earth's atmosphere;

2. what are the influences on these frequencies of the hour of the day, the season, the geographical location and solar activity;

3. what deviations in propagation direction can be expected by the penetration of the ionosphere;

4. what, if any, will be the differences in propagation between in-going and out-going signals relative to the earth;

5. are special phenomena to be expected that do not occur in transmission between two points on earth;

6. what is the possible influence of the troposphere on wave propagation to and from extraterrestrial objects?"

In addition to the foregoing, the United States Preparatory Committee-International Radio Conference, which is considering the program of C.C.I.R. Study Group VI in anticipation of the IXth Plenary Assembly of the C.C.I.R. to be held in Los Angeles in April 1959, has circulated a proposal based upon findings that "observation of radio emissions of the first earth satellite have already yielded valuable information about the ionosphere, as well as about problems of space travel," and the Committee recommends that "clear channels be set aside for the use of satellite and space ship emissions." These observations and recommendations were timely, as they are available for consideration by C.C.I.R. Study Group VI in its Geneva meeting during August 1958. The proposals for the service as foreseen for the present are reproduced in the attached paper (see Annex).

It is proposed the C.C.I.R. study and modify or confirm these needs for the astronautical services and invite the I.F.R.B. to make the appropriate frequency allocation proposal for the consideration of the Administrative Radio Conference convening in August 1959.

ANNEX

I. PROPOSALS TO SATISFY THE FREQUENCY REQUIREMENTS FOR ASTRONAUTICAL SERVICES

In order to assemble as much data as are currently available on the frequency allocation needs of astronautical radio services, the Counsel for the American Rocket Society (Andrew G. Haley) has availed himself of the advice of an informal and entirely unofficial panel of renowned scientists.

Tentative proposals for frequency allocations were accepted by Counsel on the basis of information finally sifted at the May 13, 1958, meeting. Those proposals are set out herein. Generally, the Panel has suggested that an immediate need exists for frequency allocations for the astronautical radio services in the areas of 20, 40, 100, 150, 300, 450, 1,000, 4,500, 10,0000, 20,000 and 35,000 Mc/s. The requirements can be substantiated as desired.

a) *20 Mc/s and 40 Mc/s areas*

With respect to the 20 and 40 Mc/s areas of the spectrum, Dr. Richard W. Porter [1] set forth the thinking of the Panel as follows:

"Experience gained from the observation of transmissions from the Russian Sputniks on the frequencies around 20 and 40 Mc/s has shown a definite need for continuous recording in connection with ionospheric experiments. It is not necessary to set aside large numbers of frequencies in these ranges, but a definite need exists for the use of one and maybe two frequencies in both the 20 and 40 Mc/s areas of the spectrum for experimentation involving the effect of the ionosphere on radio propagation from satellites to earth."

Counsel suggests the frequencies 20.01 and 37.00 Mc/s. Regarding these two frequencies, Counsel agrees that any other specific frequencies in the same area would be equally satisfactory. Depending, therefore, on the needs of other users of the frequencies, a slight change could be made in this part of the proposal, if necessary.

b) *100 Mc/s area*

Considerable experience has been obtained by the United States from transmissions in the 100 Mc/s region. John P. Hagen,[2] John T. Mengel,[3] and J. Carl Seddon [4] on behalf of the Panel have pointed out that the United States now utilizes the frequencies 108 and 108.03 Mc/s on a temporary, noninterference basis. These frequencies are particularly suitable for transmissions from the earth-encircling satellites which have been placed in orbit and which will be projected into orbit in the future. Satisfactory hardware has been developed for utilization in these frequencies. Hagen, Mengel, and Seddon point out that at this time omnidirectional transmissions from earth-encircling satellites are essential because such satellites cannot accommodate heavy equipment and power supply for directional or microwave transmission in higher frequency ranges. Hagen, Mengle, and Seddon further point out that there will be a need for use of the 100 Mc/s region for communications of the following varieties:

"Satellites to positions in space (the term "positions in space" means a natural position, such as the moon, or other than a manmade position).

"Space vehicle to position in space.

"Satellite to satellite.

"Satellite to space vehicle.

"Space vehicle to space vehicle.

"Tracking and guidance."

The Panel suggests, therefore, the allocation of the frequency band 107–108 Mc/s for the foregoing purposes.

This allocation would cause slight loss of spectrum space to mobile and FM

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[1] Consultant to the General Electric Company and Chairman, Technical Panel on Earth Satellite Programme of the U.S. Committee for the Geophysical Year.

[2] Superintendent, Atmosphere and Astrophysics Division, U.S. Naval Research Laboratory.

[3] Chief, Tracking Branch, U.S. Naval Research Laboratory.

[4] Section Head, Ionosphere Research, U.S. Naval Research Laboratory.

broadcasting services. However, we actually are suggesting a minimum use of spectrum space. Studies of all the frequencies in this area of the spectrum show more extreme crowding conditions, and our judgment inevitably leads to suggesting the frequencies indicated, namely, between 107–108 Mc/s, inclusive.

The request for 1 Mc/s of spectrum space in this region is not unreasonable when it is considered that within the next year radio transmitters in some 40 or 50 Earth-encircling satellites will be sending data to Earth. Mengel and Seddon estimate that up to 50 satellites will be operating within one year. Mengel reports that tracking that number of satellites becomes an impossible problem if additional spectrum space is not allocated immediately. Mengel also observes that it would be unwise to allocate numerous single frequencies throughout the spectrum for transmissions of this character, and he urges that the various frequencies allocated for these purposes be concentrated in a single continuous band of the spectrum.

c) *150 Mc/s*

Hagen, Mengel and Seddon also point out that so-called command frequencies are required for transmission from earth to present satellites, and such frequencies will certainly be necessary for future operations. The Panel suggests that the frequency band 148.0–150.8 Mc/s be allocated for command frequency usage in the astronautical radio services. Here again the Panel encounters a need to displace some present users. But the Panel believes that Earth-to-satellite control or "command" is so vital as to merit such treatment. Seddon points out that at present we have satellites in service whose transmissions may well go on for 200 years. A means of "commanding" these satellites must be on hand, and the Panel finds the 148–150.8 Mc/s band best suited for this function.

d) *300 and 450 Mc/s areas*

The Commander, Army Ballistic Missile Agency, Redstone Arsenal, Alabama, has informally advised Counsel (on behalf of Panel members von Braun and Saunders) that that Agency agrees with the general proposals of the Panel. In addition, the Army Ballistic Missile Agency advises that "frequency bands in the following frequency ranges are considered essential":

* * *

"(B) 200–300 Mc/s for MSL telemetry MSL and Satellite TV.

"(C) 45–500 * * * MSL tracking and space communications."

Counsel adopts this proposal and urges the allocation of a band between 320 and 328.6 Mc/s for the former purpose and a band between 450 and 455 Mc/s for for the latter purpose. These proposals require a certain amount of displacement of existing services, and the Panel emphasizes that experience may permit of reduction of the bandwidth now requested. For instance, a narrower band for television operation may be evolved from future work in the field.

e) *1000 and 4500 Mc/s area*

Frequencies in the order of 1000 Mc/s will be highly essential for space communications needs. Dr. John R. Pierce[5] reported to Counsel that his best estimate "for ground-to-satellite communications is somewhere between 1000 and 6000 Mc/s." Furthermore, Dr. Pierce states that "as many and as broad as possible channels (20 Mc/s and more) should be acquired within these limits." The Panel has suggested that a need exists for frequencies in the 1000 Mc/s range for communications between earth and space vehicles and between earth and positions in space.

Considering the present congestion in the 1000 Mc/s range and the magnitude of the operations proposed to be conducted, Counsel takes the position that the frequency band 890–942 Mc/s should be allocated for use by astronautical radio services. The astronautical radio services might well share a part of this frequency band with industrial, scientific, and medical radio services presently authorized. It is contemplated, however, that eventually the astronautical radio services would require exclusive use of all of this band.

A band at least 20 Mc/s wide in the 4400 to 4500 Mc/s region will be needed, according to Pierce, Hagen, Mengel, and Seddon. Frequencies in this band would be used in conjunction with the operations in the 890–942 Mc/s band. The 4400 to 4500 Mc/s band is not as congested as lower bands, but some displacement may occur. The Panel believes that room for some of the displaced services might be

[5] Director of Research, Electrical Communications, Bell Telephone Laboratories, Incorporated.

found in higher parts of the spectrum, which are presently not utilized or allocated.

f) *10,000 Mc/s area*

Dr. Porter reported to Counsel that there is a substantial need for accurate positioning measurements of space vehicles and positions in space. Dr. Porter believes that frequencies in the order of 10,000 Mc/s are well suited for precision tracking. Accordingly, the Panel suggests that frequencies in the approximate range of 10,000 to 10,100 Mc/s be allocated to the astronautical radio services. Displacement in this area should be a less critical problem than in lower parts of the spectrum. At present, a 500 Mc/s band is set aside for amateurs. The Society's proposal is to reallocate only 20% thereof to astronautical radio services.

g) *15,000 to 40,000 Mc/s area*

The members of the Panel agree that the use of frequencies in the 15,000 to 40,000 Mc/s portion of the spectrum by astronautical radio services will become a reality at an early date. Dr. Pierce stated to Counsel, for example, "for communication outside the earth atmosphere frequency bands beyond 20,000 Mc/s and up to 100,000 Mc/s will be most useful." Counsel agrees with this view and takes the position that the frequencies in this range will be required for astronautical radio services of the following types:

Between earth and positions in space.

Between space vehicles and positions in space.

Between two or more positions in space.

Between two or more space vehicles.

After reviewing the present frequency allocations the Panel suggests the exclusive allocation of the frequency bands 17,500–20,000 Mc/s and 36,000–38,000 Mc/s to the astronautical radio services.

No displacement would occur if this proposal were implemented. The areas specified are not now allocated for *any* service.

II. BANDWIDTHS

As is indicated in the above discussion of various frequencies, in most instances the Panel has informally suggested a specific bandwidth for each allocation. The Panel considered at length minimum bandwidths which could be temporarily utilized in the event that the allocation at this time of the entire band requested proved to be unfeasible. As a general proposition the Panel decided that with one or two exceptions the bandwidths should be at least 1% of the frequency range, e.g., a bandwidth of 1 Mc/s at 100 Mc/s, 10 Mc/s at 1000 Mc/s, and so on. The computation of bandwidth under this formula represents a *minimum* amount of spectrum space, and it should be emphasized that Counsel urges very strongly the allocation of greater amounts of spectrum space wherever possible.

III. SUMMARY AND CONCLUSION

The presently known frequency requirements of the astronautical radio services are tabulated below. These frequency requirements were carefully considered over the last six months, on the basis of theory, and experience in observing orbits of satellites, and the list was prepared on May 13, 1958. These proposals are by no means final, as developments in the astronautical sciences will require changes in the future as space flight develops. Likewise, the terminology used in the proposed allocations will change. Already, in the few months since the Society proposed new definitions for services, changes have taken place. Thus, new terms will be used herein for descriptive purposes. Those terms will be defined in future documents to be filed by the Society with

the Federal Communications Commission and the International Organizations concerned on appropriate occasions.

Frequency band kc/s	Allocation to services (worldwide)	Footnotes
20,010	Astronautical mobile (Ionospheric propagation)	

Frequency band Mc/s	Allocation to services (worldwide)	Footnotes
37.00	Astronautical mobile (Ionospheric propagation)	
107.0–108.0	Astronautical mobile Astronautical radiolocation (tracking)	
148.0–150.8	Astronautical radionavigation (command)	
320–328.6	Astronautical mobile (telemetry and television)	
450–455	Astronautical mobile Astronautical radiolocation (tracking)	
890–942	Astronautical mobile	The frequency 915 Mc/s is designated for industrial, scientific and medical purposes. Emissions must be confined within the limits of +25 Mc/s of that frequency. Radiocommunication services operating within those limits must accept any harmful interference that may be experienced from the operation of industrial, scientific and medical equipment.
4,380–4,400	Astronautical mobile	
10,000 to 10,100	Astronautical mobile Astronautical radiolocation	
17,500–20,000	Astronautical mobile Astronautical radiolocation	
36,000–38,000	Astronautical mobile Astronautical radiolocation	

Appendix C

Federal Communications Commission and American Rocket Society Space Radio Frequency Allocations Proposed in Docket No. 12263

FCC	ARS
None	1.3–1.5 mc (Space)
25.6–25.65 mc (Earth/Space)	25.6–25.65 mc (Earth/Space)
None	37.00 mc (Earth/Space)
None	38.00 mc (Earth/Space)
Unspecified frequencies in 100–150 mc band (Earth/Space, Space)	148.0–150.8 mc (Earth/Space, Space)
None	216–220 mc (Earth/Space, Space)
None	225–235 mc (Earth/Space, Space)
None	250–260 mc (Earth/Space, Space)
None	390–400 mc (Earth/Space, Space)
None	410–420 mc (Earth/Space, Space)
None	430–435 mc [1] (Earth/Space, Space)
None	960–970 mc (Earth/Space, Space)
None	1435–1535 mc (Earth/Space, Space)
1700–1725 mc (Earth/Space, Space) see note below.	1700–1775 mc (Earth/Space, Space)
1825–1850 mc (Earth/Space, Space)	1775–1850 mc (Earth/Space, Space)

[1] Non-government users of the frequencies displaced in this band should be shifted to areas now reserved for government allocations where possible.

Note.—The only change proposed by the Society is with respect to bandwidth. No objection is made to the fundamental allocation proposed by the Commission.

2275–2300 mc (Earth/Space, Space) see note above.	2225–2300 mc (Earth/Space, Space)
None	2800–3000 mc (Earth/Space, Space)
None	3500–3900 mc [2] (Earth/Space, Space)
None	4400–5000 mc (Earth/Space, Space)
None	5400–5600 mc (Earth/Space, Space)
None	7125–7200 mc (Earth/Space, Space)
8300–8400 mc (Earth/Space, Space)	8300–8400 mc (Earth/Space, Space)
15150–15250 mc (Earth/Space, Space) see note above.	15150–16150 mc (Earth/Space, Space)
31500–31800 mc (Earth/Space, Space) see note above.	31500–32500 mc (Earth/Space, Space)
None	80000–81000 mc (Earth/Space, Space)

[2] Some displacement of amateur operation may be required in this band.

ITEM 4

INTERNATIONAL TELECOMMUNICATIONS UNION (ITU)

The mission of the ITU is threefold:

(1) To maintain and extend international cooperation for the improvement and rational use of telecommunication;

(2) To promote the development and most efficient operation of technical facilities by establishing standards and operating rules in order to improve telecommunication services, increase their usefulness, and, as far as possible, make them generally available;

(3) To harmonize the actions of nations in the attainment of these common ends.

Briefly stated, the ITU engages in four general courses of action:

(1) It is instrumental in allocating radio frequencies and registering radio frequency assignments;

(2) It seeks to establish the lowest rates possible, consistent with efficient service, and taking into account the necessity for keeping the independent financial administration of telecommunication on a sound basis;

(3) It promotes measures of insuring the safety of life through the cooperation of telecommunication;

(4) It makes studies and recommendations and collects and publishes information for the benefit of its members.

To implement the work of the ITU, the 1947 Convention set up an eleven-member International Frequency Registration Board (IFRB), the duties of which are set forth in Article 6 of the Convention:

(a) To effect an orderly recording of frequency assignments made by the different countries so as to establish, in accordance with the procedure provided for in the Radio Regulations, the date, purpose and technical characteristics of each of these assignments, with a view to insuring formal international recognition thereof;

(b) To furnish advice to Members and Associate Members with a view to the operation of the maximum practicable number of radio channels in those portions of the spectrum where harmful interference may occur.

The Convention also set up an International Radio Consultative Committee (C.C.I.R.) which is empowered to study and make recommendations on technical radio questions and operating questions, the solution of which depends principally on considerations of a technical radio character.

The duties of the Secretariat are:

(a) To collect and publish data both national and international regarding telecommunication throughout the world;

(b) To collect and publish such information as would be of assistance to Members and Associate Members regarding the development of technical methods with a view to achieving the most efficient operation of telecommunication services and especially the best possible use of radio frequencies so as to diminish interference; and

(c) To publish periodically, with the help of information put at its disposal or which it may collect, including that which it may obtain from other international organizations, a journal of general information and documentation concerning telecommunication.

Chapter IV of the General Regulations annexed to the International Telecommunications Convention provides that experts of scientific organizations and of international organizations may appear and participate at the Conferences and work with Committees and Subcommittees, but such experts will have no vote. Scientific organizations may present petitions and resolutions to an ITU Conference with the consent of the official head of the delegation of the country concerned.

Annex 5 to the Convention contains an agreement between the United Nations and the ITU. The Agreement provides for reciprocal representation of the ITU and the United Nations at their respective meetings.

Item 5

Federal Communications Commission—Letter to Press Wireless Regarding Space Communication

The Commission addressed the following letter to Press Wireless, Inc., New York City:

"This is with reference to your application for special temporary authorization for your Centereach, New York, and Belmont, California, fixed public press stations, to furnish cue and contact control in connection with program reception service with manned vehicles or missiles traveling in outer space initiated by and under the control of appropriate (a) United States Government or (b) U.S.S.R. Government agencies. Reference is also made to our letters of October 22, 1958, and November 14, 1958, in reply to your letters of October 10, 1958, and October 28, 1958, respectively, relative to your inquiries as to whether your Company's present licenses issued by, and tariffs filed with, this Commission enable it to provide communications services with manned satellites, space platforms, or space expeditions.

"The instant applications would appear to be premature and otherwise not in accordance with the Commission's Rules, as set forth below.

"As was indicated to you in our above-referred to letters of October 22, 1958, and November 14, 1958, in any application or applications which Press Wireless might submit to the Commission for special temporary authorization to provide communications services with specific manned satellites, space platforms, or space expeditions, it should first have made arrangements and secured permission to communicate with such vehicles with the appropriate United States or foreign government agency or agencies having control over the particular expedition into outer space, as well as to submit the technical and other data required by this Commission in connection with such applications. In this connection, your attention is directed to Section 6.28 of the Commission's Rules applicable to requests for special temporary authorizations. Since your instant applications fail to indicate that you have made the necessary arrangements and secured the approval of the appropriate government agencies (either United States or U.S.S.R.) to communicate with any specific manned satellite, space platform, or space expedition they are not in accordance with the above-referred to section of the Commission's Rules and are therefore being returned to you pursuant to the provisions of Section 1.445 of the Commission's Rules applicable to defective applications involving common carriers.

"The return of the subject defective applications is without prejudice to your filing further applications for similar authority when you have more complete and detailed information with respect thereto and have made the necessary prior arrangements referred to above.

"In your covering letter of December 4, 1958, accompanying the subject applications, you indicate that arrangements to permit immediate contact with the personnel of manned space vehicles via the appropriate agency's communications media appears possible only on a 'last minute' basis and that the subject applications are filed in order to permit immediate contact. While the exact day, hour and minute a particular manned space vehicle goes into space and certain other last minute details might not be known very far in advance, such important arrangements as to whether and by whom the appropriate agencies wish contact, if any, to be made with personnel of each particular space vehicle what frequencies are to be used in such contact, etc. can surely be made days in advance of the actual flight into space. It is this type of arrangements the

Commission expects Press Wireless, and any other common carrier under its jurisdiction who wishes similar authority to make with the appropriate agencies concerned and to submit proof thereof to this Commission prior to consideration by us of any applications you may file for special temporary authorization in this matter. As explained above, when the Commission is assured that you have permission to contact specific manned space vehicles and have furnished the other appropriate technical information necessary, we can act upon such applications promptly. It will not be necessary then for you to submit the last minute minor details to which you refer."

CONCLUSIONS

(1) Within the framework of new statutes and international agreements, and of the pertinent existing statutes and international treaties, lawful use must be made of radio frequencies for all forms of astronautical communications. Requirements of international law have been observed only once by any nation since the launching of Sputnik I. Even during the past few months "Mechta" broadcast on the most sacred of all frequencies, the worldwide allocated "standard frequency," better known as the "time signal" frequency; and also on the video part of Television Channel 8; used in Indianapolis, Des Moines, Syracuse, Cleveland, Portland, Dallas, Houston, and numerous other American cities. I venture to say that as time goes on the international obligations of the nations of the world will be more and more ignored—if the lawyer does not intervene and make himself heard in the Congress of the United States, in the United Nations and in the International Telecommunication Union. Many radio frequencies are needed for communication in the Space Service and in the Earth/Space Service, that is between earth and vehicles in space, and between vehicles in space and earth; between earth and positions in space; and positions in space and earth; between two or more positions in space; between two or more space vehicles. Radio frequencies are essential, not only for all forms of communication between the fixed and mobile points I have thus indicated, but also for numerous other purposes such as for telemetering, tracking, guidance, radiopositioning (radar), and so on.

(2) Any nation sending radio equipment into space (except equipment destined for probes beyond Mars and Venus) must be required to be able to command such radio equipment to stop transmitting—or the equipment may be the source of interfering signals for decades to come. With the improvements in solar batteries and the use of outer orbits where sunlight is constantly available as the power source, radio equipment in satellites may well, in a very short time, be capable of indefinite life, and therefore of indefinite interference, unless controllable. Pertinent facts must be ascertained by this Committee.

(3) No object should be placed in any orbit in outer space which cannot be guided back to earth or destroyed by some other means, such as being guided into the surface of the sun. The regulated use of radio frequencies for such guidance or "destruct" purposes is of urgent and immediate importance. The nations of the world—including the U.S.S.R., U.S.A., United Kingdom, Peoples' Republic of China, and so on, contemplate sending scores of "Sputniks"* into space. Many of these undoubtedly will attain permanent orbits. Remember, it takes about as much energy to get one of these objects back to earth as it does to place it into orbit initially. As a practical matter, it would be almost impossible to divert an earth-orbiting object while outside the earth's atmosphere, without having placed on the object initially a mechanism with which to purposefully divert the object. One cannot destroy the object by ordnance, as even if blasted the fragments would continue on orbiting and probably become even a greater *menace to navigation and safety in space.* Therefore, we must now enact international regulations requiring that before any object is sent into space it must be equipped with apparatus whereby it may be commanded back to earth at a safe location on earth.

(4) By the same token, any object sent into space must be under the control of the sender so that on completing its orbital life the responsible party may guide the object back to an area *safe for mankind.* In other words, as "Sputniks" become larger there is no assurance whatsoever that they will atomize on their

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*The term "Sputniks" is used only for convenience to identify all earth orbiting satellites and space probes.

return to earth. The fact is that many of these objects will come back in large and lethal metallic chunks and there is always the possibility that these metallic monsters will hit congested population areas. Assumptions of adverse odds really afford no criteria of safety. Only a few months ago, in America, and specifically at Nellis Air Force Base in Nevada, it was customary for jet planes to describe a run over a certain radio path, ascend high into the sky, and then perform a penetration dive. It was believed that this maneuver was entirely safe, but the odds that any injury would occur to commercial aviation were so remote that notice should not be taken thereof. However, a United Airlines DC–7 in full and cloudless daylight, engaged in a routine scheduled flight, with more than 40 passengers aboard, was crashed into by one of these jets during the course of the penetration dive, and all aboard each craft were killed. We cannot assume that the returning debris of numerous "Sputniks" will not cause damage on earth. It is fundamental that safety precautions be enacted and enforced. Of great importance to future manned space navigation is keeping the "space ways" clear for the safety of life and property in space. This means we must provide now against all forms of space derelicts, and radio controls are vitally important in this matter.

(5) At the present time intercontinental ballistic missiles and missiles of lesser range are being tested over wide areas of the earth's surface, and by several nations. With respect to all such firings it should be required that flight plans and radio frequency coordination plans be filed with appropriate agencies such as ICAO and ITU or a new office in the United Nations, for the advance knowledge and guidance of surface craft and installations and for the general "peace of mind" of humanity.

(6) All long-range missiles and all "Sputniks" should be required to carry apparatus which will render them readily identifiable. A system of radio signals would be one way of effecting the identification.

(7) Agreements among nations with respect to the use of television, photography, and any observational equipment whatsoever, should be immediately undertaken.

(8) There should be organized within the United Nations or by universal agreement as a result of special treaty making, a Commission to define the limitations of sovereignty of the nations of the earth. Three problems are involved: (a) stating the present international law with respect to limitations on jurisdiction; (b) reconciling final determinations relating to jurisdiction and sovereignty with the statutes of the individual nations of the earth (this means that the individual statutes of each of the nations of the world relating to jurisdiction and national sovereignty may have to be changed); and (c) enacting statutory and constitutional legal formulations "covering in" the new dimensions of outer space from all aspects—technical and sociological. I have pointed out in numerous lectures and articles that all existing treaty law and all existing national statutes define the limit of national jurisdiction to be within "airspace". There simply is no law for the area beyond "airspace", which we now call "outer space". There seems to be, on the part of the Foreign Ministries of many nations, a strange indifference to this question of defining jurisdiction. But there is no way to escape the problem. I will not labor the point on this occasion, but I would like to leave with you the thought that this is one of the most urgent and important of all problems. We are occasionally faced with strange and tormented arguments such as those concerned with the nature of the X–15. Some persons claim that because it is airborne for a portion of its flight, such fact has some sort of continuing jurisdictional implication. This is not the case. As long as it is airborne it is subject to the jurisdiction of the nation in the airspace over which it travels. When it is no longer airborne—and is beyond airspace—and is traveling by centrifugal force, the object is in outer space and no present law appertains to its movement. The same precepts are true with respect to any objects (such as Sputniks) which are hurtled into outer space. Tormented arguments are also made with respect to the extent of "airspace" such as the claim that "air" or atmosphere extends 10,000 miles or 200,000 miles. Such arguments are completely unscientific—as pointed out herein. See "The Law of Space—Scientific and Technical Considerations", an appendix in Item 3 hereof. These are scientific problems which must be handled legally in the near future. Thus, in the background of all the foregoing, as I have pointed out since my American Rocket Society talk in 1955, we must face the space law problems of drafting, administering, and enforcing regulations relating to communications, safety, sanitation, health, asylum, equipment, navigation, emigration, and immigration, all of which regulations would conform to the most universal and en-

lightened principles of freedom and the use of property, and promulgate a code defining public and private liability for damage.

(9) My colleague, Dr. Welf Heinrich Prince of Hanover, and I, addressed the students and faculties of 26 great American Universities concerning the problems of jurisdiction and sovereignty in positions in outer space such as the moon. Venus, Mars, and so on; and also with respect to mobile vehicles and orbiting objects in outer space. We pointed out that through the medium of the United Nations or by universal treaty making, at this time the moon and other natural objects should be placed beyond the jurisdictional or sovereignty claims of any nation on earth. The moon may be alighted upon by human beings within the next five or ten years, and if in the meantime we do not reach an understanding concerning the moon the nation achieving this great scientific acquisition may well, under classical principles of terrestrial international law, claim sovereignty over the moon. Great military leaders have said that the nation which controls the moon will also control the earth. The policy of inaction and inattention to this problem may well haunt those who are responsible for such inaction. If Nation X establishes a base on the moon, to the dismay of Nation Y, it will be found that numerous small nations of the earth will really sympathize with Nation X because of its great achievement and on the grounds of fair-play—and will afford little sympathy to Nation Y, which has lagged behind and which has not taken the initiative in guarding against the very problems which would arise.

CURRICULUM VITAE

ANDREW G. HALEY (1735 DeSales Street NW., Washington 6, D.C.), President of the International Astronautical Federation and General Counsel of the American Rocket Society (member of law firm of Haley, Wollenberg & Kenehan), was born in Tacoma, Washington (November 19, 1904), and was educated at George Washington University (A.B. degree) and Georgetown University (LL.B. degree). A lawyer by profession, he has devoted a major part of his lifetime to "working with his hands in rocketry" and to practicing law in the technical fields, namely, radio, television, hydroelectric power, and in all branches of rocket propulsion. Prior to World War II he was Counsel for the Federal Communications Commission. He was cofounder, President, and Managing Director of Aerojet Engineering Corporation (now the world's largest rocket company) during the period of World War II. He was lecturer, First Jet Propulsion School, organized under military orders (1943). After he resigned as President of Aerojet, he served for a year as Adviser on Aircraft to the United States Senate Special Committee investigating the National Defense Program and wrote a report for that Committee urging Congress to "step-up" support of rocket research and development.

He is president of Missiles-Jets & Automation Fund, Inc., and Missiles-Jets & Automation Management Company.

Mr. Haley has advocated the cause of astronautical communications from the very inception of the requirement. On behalf of astronautical radio, representing the IAF and the ARS, he attended the Eighth Plenary Assembly of the International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU) in Warsaw, Poland, August 31–Sept. 5, 1956, during which he presented an astronautical radio program based upon recommendations of scores of scientists from throughout the world. He attended the CCIR sessions in Moscow, USSR, in May–June 1958, and in August 1958, he attended, on behalf of the same organizations and for the same purpose, the CCIR meeting in Geneva. He is Chairman of the Government-Industry Arrangements Committee for the Ninth Plenary Assembly of the CCIR in Los Angeles in April 1959, and he is a Delegate to the Administrative Radio Conference of the ITU in Geneva in August 1959. Within the United States he has appeared before the Federal Communications Commission and the State Department Radio Preparatory Committees as advocate on behalf of the complete astronautical radio allocations plan—the scientific basis of which was furnished by leading scientists from throughout the world. He has obtained full recognition for the IAF by the ITU, which includes the right to participate in assemblies and conferences of the ITU on a reciprocal basis without charge to the ITU. He has also obtained the promulgation of far-reaching proposals for nonmilitary and worldwide astronautical radio allocations from agencies of the U.S. Government.

In 1951 he was an American Rocket Society Delegate to the Second International Astronautical Congress in London and was elected Vice President of the International Astronautical Federation (IAF), to which office he was reelected at the Third Congress of the IAF held in Stuttgart in 1952 and at the Fourth Congress of the IAF held in Zurich in 1953. As Vice President of the IAF he attended the Fifth Congress held in Innsbruck in 1954, and he attended the Sixth Congress of the IAF held in Copenhagen in 1955 as Chairman of the Delegation from the American Rocket Society. He was Chairman of the International Affairs Committee and a member of the Finance Committee of the IAF until taking office as President. He was Chairman of the Delegation from the American Rocket Society to the VII International Astronautical Congress (IAF) held in Rome in September 1956, and to the VIII International Astronautical Congress held in Barcelona October 7–12, 1957. He was elected President of the IAF in 1957 and re-elected at the IX International Astronautical Congress held in Amsterdam in August 1958. He organized and was Chairman of the First Colloquium on the Law of Outer Space held at The Hague on August 29, 1958. He is a member of the Permanent Legal Committee of the IAF and Vice Chairman of the Committee on Space Law of the American Bar Association.

Mr. HALEY. I will endeavor to limit myself to 10 or 15 minutes, Mr. Chairman.

I would like to point out to the committee that I am not a novice either in communications or in rocket work. I was born in the State of Washington and was fortunate enough to have as my Senator when I was growing up as a kid, Clarence C. Dill.

When I was here going to Georgetown University, the law school, Clarence C. Dill was a member in those Republican days of the Senate Interstate Commerce Committee. I needed a little money every now and then to help pay grocery bills when I was going to school, and he would give it to me for work on his project in writing the Communications Act of 1927.

So I have a very vivid memory of the Communications Act of 1927. Thereafter, when Mr. Roosevelt came into authority I was appointed as attorney for the Federal Radio Commission, in those days; and I was also helpful, I think—I hope I was—to Senator Dill in the Senate Interstate and Foreign Commerce Committee in writing the Communications Act of 1934.

So that is the part as to communications. I have worked in the field ever since then.

Also during the course of my work in communications I became acquainted with many of the greatest scientists in America. Among these was a man who had a great deal of influence on my life, Dr. Theodore von Karman, who was chairman of the Aeronautical School of California Institute of Technology. Dr. Theodore von Karman had been given the job by special order of the teachers' staff in those days under the direct aegis of Gen. H. H. Arnold at Cal. Tech to do the first work in rocketry.

I was with him from the very inception of this work, not working in rocketry but as a personal attorney for the scientists who were working in the field—Frank Williams, Martin Summerfield, Clark D. Milliken, and many, many others.

So we started out in 1939 and then gradually I became more closely associated with it in 1940 when we decided under the direction of General Arnold to organize a production facility, which Cal. Tech could not have because it was an eleemosynary educational institution.

So we had to organize this. I did it for them. One time I had all the stock of Aerojet. But nevertheless, for the next 4 years all during the wartime I was president and managing director of Aerojet.

Most of the people who are now running Aerojet were hired during that period of time. As I say, the boys who actually do the work—the scientists, the vice presidents who carry on the various projects.

With that background of mine, I would like to emphasize this thought. When I was called by your committee staff to testify before this committee, I wondered what business I had testifying before the committee on communications. I thought the idea was generally to limit myself to communications. So I really put in a good deal of time in the past 4 days in figuring out whether I should be here testifying before you or not.

As a lawyer, I always like to look at the jurisdictional problems involved and see whether this is the place to be. Am I out of court? Am I out of order?

I came up with this conclusion that this is about the only forum in the House of Representatives that is available for the general discussion, for the overall discussion, of problems of astronautics, and specifically of the problems of astronautical radio.

Nothing could be more stark and nothing could be more sui generis, unique, than the field of astronautics—any aspect of astronautics. I remember in 1927, from personal knowledge; I looked over the old notes and over all the legislative background and history of it. There never was a thought, there never was a mention of such a thing as space communications. It wasn't even dreamed of.

Also, when it comes to the Constitution of the United States, we also find the commerce clause and so on. There never was any thought of anything else. It was intercourse first, and they later changed it to commerce—among the nations of the Earth and between States and so on.

So never in the history of legislation has there ever been any thought given to the subject of commerce in outer space or outer space in any field at all. There is no statute in the United States that has to do with outer space—nothing.

The only thing we have now, the only legislation we have now, are these resolutions in these committees.

So we are indeed in a very, very extremely unique position here. This only comes to jurisdiction. What committees might have jurisdiction? I can see right away that there might be some jurisdiction inherent in the Judiciary Committee because some day it will be necessary, I think, to amend the Constitution of the United States with respect to problems of outer space—this new dimension.

Mr. FULTON. Could I interrupt you one minute to ask, may we hear your ideas, not on the jurisdiction of congressional committees, but on the aspects of communication? We are going to be very limited on the time we can give. We may get a rollcall.

Mr. HALEY. I am almost there.

Mr. FULTON. I would rather not have a discussion on jurisdiction at this time. It gets us into a field that is beyond this scope.

Mr. HALEY. Interstate commerce?

The CHAIRMAN. I would say this to Mr. Haley. We are having no jurisdictional problems in the committee. What we are doing, we are working thus far with agreement with the other committees on what is our jurisdiction.

Generally speaking, I can say this. This committee has jurisdiction of space, and that is what the resolution creating the committee says—which covers, as you have said, in a general broad way every aspect of space.

Mr. FULTON. May I point out there, while you are talking jurisdiction, this committee has expressed jurisdiction over the control of space under subsection (f) of the authorizing clause in the act passed in 1958.

Mr. HALEY. Of course I am also looking at the resolution of January 4, I think it is.

The CHAIRMAN. Also we have expressed jurisdiction over science in all scientific matters.

Mr. HALEY. Of course they state in the fields of astronautical research, development, including resources, personnel, equipment, facilities, outer space, including exploration, control thereof, air space and air law—air law and space law.

So there is no question but I am a lawyer, after all. I am not here as a scientist testifying about technical matters. I am here as a lawyer testifying about the objective aspects of the committee functioning, and also testifying concerning the communications problems.

I shouldn't get foolish testifying about problems I know do not belong to this committee, you see. I want to be sure to let you understand I am not going beyond the scope of this committee. In other words, if I were talking about a space ship——

The CHAIRMAN. You go right ahead, sir.

Mr. HALEY. If I were talking about a space vehicle that we launch in Australia, in Melbourne, bound for London, even if it entered outer space for a brief period of time, I still would be talking about a vehicle that probably would be under the complete jurisdiction of the Interstate Commerce Committee or some other agency of the Interstate Commerce Committee, because it is obviously a terrestrial type of vehicle. We must keep these things in mind.

The CHAIRMAN. Let's stay out of the jurisdiction of the Interstate Commerce Committee. Let's confine ourselves to space.

Mr. HALEY. Therefore, to make the story short, and, after all, we have put this statement in the record, I think this committee must do all the substantive things required to implement what the Federal Communications Commission has called space service and Earth space service.

Now, what are these three services and Earth space service? I can tell you that in just 1 second. The space service and Earth space service says the services that are the designations, the definitions, of the provision of such service between Earth and vehicles in space; between vehicles in space and Earth; between Earth and positions in space; and positions in space and Earth; between two or more positions in space; between two or more space vehicles.

Radio frequencies are essential, not only for all forms of communications between the fixed and mobile points I have just indicated, but also for numerous other purposes such as for telemetering, tracking, guidance, radio positioning, radar, and of course the act and performing of the function of the active and inactive repeater stations in space which these three gentlemen have discussed this morning.

It is essential—to get back to the sore subject here of jurisdiction—that this committee examine all these points. This is your duty. Beyond saying that as a lawyer, I don't think there is much else to say. I can point out some other substantial areas where you must obtain information and legislation.

As one of the young and newer services which is not contemplated anywhere else in law or in the Constitution, we have such problems as this. We are sending out sputniks, Explorers—we use the term sputniks as an example—without having any control mechanism on these vehicles. In other words, we send them out with radio devices. They can operate almost indefinitely with new solar batteries and so on. We have no means of turning those radio devices off.

So these space vehicles, especially the inner orbiting vehicles, can be a constant source of interference to terrestrial uses, to uses of radio by mankind.

All right, here is a matter of safety of life and property in space itself. We are sending these same vehicles out and one is lost for the time being. These vehicles have in many cases, and will have more and more, indefinite orbiting periods.

For example, I think that Vanguard No. 2 will have a lifetime of 2,000 years, probably. Here it is in outer space without any means of getting it back or controlling its orbit. Remember, it is just as difficult and requires almost as much energy to get that vehicle down without control as it is to get it up.

So there it is, a constant hazard, a menace, to safety of life and property in space. So here is another place where we must have legislation some place along the line to make sure that these vehicles are controlled.

Then again we have the objects such as the first three sputniks and other vehicles which we have sent into outer space. These come back to the Earth willy-nilly, depending upon just how they graze the atmosphere over a period of time.

The Naval Research Laboratory has pointed out that these objects come down in big chunks of metal. Here again we have no control over them. They may come down on top of Washington, D.C., or on top of the Kremlin or Buckingham Palace or most any place and do great damage.

There is no real excuse in saying that the percentage of these objects hitting something is too small, because they are not too small. They can hit something. We have the example of the Nellis Air Force Base where the jet would fly a radio beam into Las Vegas, go up 40,000 or 50,000 feet, and then make a penetration dive. They said it was perfectly safe.

It wasn't perfectly safe because it hit a DC–7 filled with civilian passengers, 40 civilian passengers. Everybody got killed. So these things are not trivialities.

Furthermore, it is just good business and good housekeeping to be sure that these things are taken care of.

So legislation should be thought up between flight plans and so on. When it comes actually to the use of radio in outer space, we have nothing but a history of violations so far.

All three Russian sputniks used a frequency of 20.005 megacycles and a frequency of 40.002 megacycles to transmit back to earth. These frequencies are assigned by international agreement. The first is a standard broadcast frequency. This frequency operates WWV, the

time station, the time signals, for all the world, which are carried on this 20 megacycle frequency. Yet the Russians were using it.

It is true the interference wasn't bad because there was only one sputnik using it at a time. But there was some interference, and we know that within the next 4 or 5 years there may be two or three hundred of these vehicles in space.

They also used 40.002 megacycles, and this frequency is allocated to region 2 of the world for safety of life and property in the air. This is wrong. Mechta, the Russian moon probe, used 107 megacycles. This is channel 8 television in America. This particular channel is used for television transmission in Indianapolis, Des Moines, Syracuse, Cleveland, Portland, Dallas, Houston, and other American cities.

Certainly it went out so far and so fast it didn't do much damage, but still it was a gross violation of international law. Our Explorer now is using 9.62 megacycles. This is also allocated to safety and aeronautical radio services for the safety of life and property in the air.

One of our satellites also used a part of the commercial FM frequency band, which is, of course, contrary to the FCC regulations—an allocation approved by the Government and international allocations.

As I said, I am speaking here purely as a lawyer. I think I have all the data here that supports my position. I don't think it is necessary to pursue it further, but I think this committee has a heavy responsibility in going into all of these matters, and especially the matter not of jurisdiction in the Congress of the United States but generally the jurisdiction and what Congress as a whole shall do.

We must settle substantive questions. Most of the substantive questions have very serious jurisdictional aspects to them.

Thank you very much.

The CHAIRMAN. We are very happy to have your statement.

We have one more statement set for today, Mr. Edgar M. Cortright, chief, advanced technology program for the National Aeronautics and Space Administration.

Do you have a prepared statement, sir?

STATEMENT OF EDGAR M. CORTRIGHT, CHIEF, ADVANCED TECHNOLOGY PROGRAM, NASA [5]

Mr. CORTRIGHT. I do. But I would prefer to talk with the aid of charts, if that is satisfactory.

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[5] Edgar M. (Maurice) Cortright was appointed chief of the advanced technology program in the Office of the Assistant Director for Advance Technology when the National Aeronautics and Space Administration was established on Oct. 1, 1958. Before joining the NASA headquarters staff, he was Chief of the Plasma Physics Branch at the Lewis Laboratory, in Cleveland, Ohio.

Cortright joined the National Advisory Committee for Aeronautics, the predecessor of the NASA, as an aeronautical research scientist on the staff of the Lewis Laboratory in 1948. From 1949 to 1954, he was head of the Small Supersonic Tunnels Section; from 1954 to 1958, he was Chief of the 8 x 6-foot Supersonic Wind Tunnel Branch at Lewis. In January 1958, he was appointed Chief of the Plasma Physics Branch.

A native of Hastings, Pa., Cortright served as an officer in the U.S. Navy from 1943 to 1946. He earned a bachelor of aeronautical engineering degree in 1947 and a master of science in aeronautical engineering degree in 1949, both from Rensselaer Polytechnic Institute.

During his research career, Cortright has specialized in high-speed aerodynamics, particularly problems related to air induction system design, jet nozzle design, and interactions of a jet with external airflow. He is the author of several technical reports and articles. He is a member of the Institute of the Aeronautical Sciences.

Cortright is married to the former Beverly Hotaling. Mr. and Mrs. Cortright and their two children, Susan J., 10, and David E., 8, live at 6909 Granby Street, Bethesda, Md.

The CHAIRMAN. Fine. Can you put your charts up there? We will ask these gentlemen, if they will, to part so we can see the chart. You can put the chart on that table, that platform, so everybody can see it.

I am going to ask the members of the committee here this afternoon to pay special attention to the statement from Mr. Cortright. The reason is that later on, in the handling of this deficiency appropriation bill—I think that is the bill—the part you have to say will be very relevant to that measure and it might assist us later on in handling that data.

Mr. CORTRIGHT. Thank you. Gentlemen, there seems to be little doubt now that the area of communications will benefit tremendously by use of the earth satellite. I think the testimony we had this morning is a strong demonstration by the communications experts of this country that this is a fact.

The questions that remain largely relate to when will this be achieved and what will the final techniques be, that is, just what type of communications satellites will finally end up in the commercial and military networks.

Before going into the types which we are interested in studying, I would like to review briefly the communications situation in the world today which is in such need, we feel, of assistance.

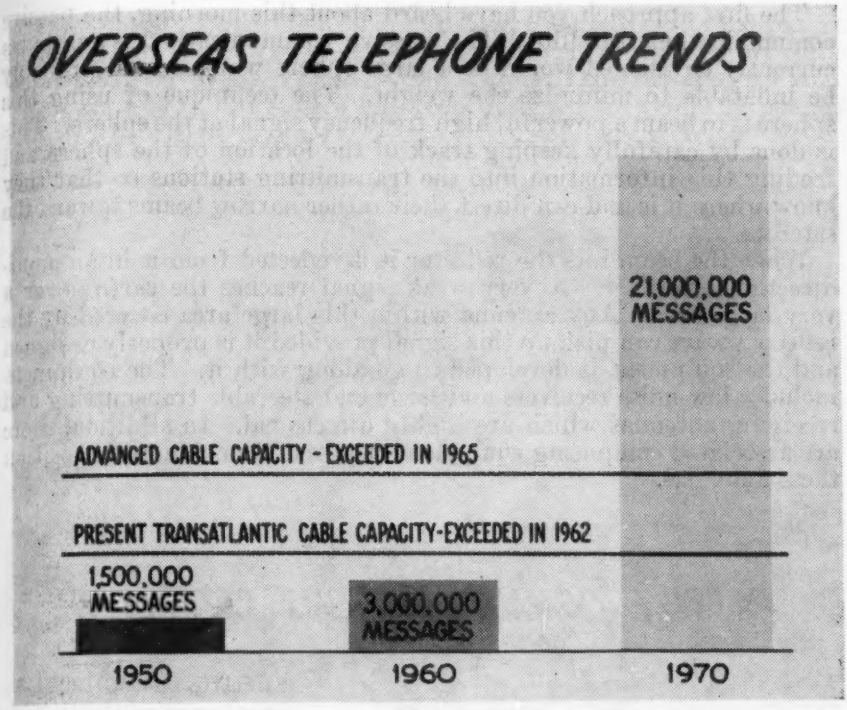
There are a few favored nations of the world which have nearly adequate communications systems. They can handle their telephone requirements, radio requirements, and a limited amount of television. However, I might say that even these most modern nations are becoming hardpressed with certain requirements such as transmittal of weather information.

Many areas of the world have virtually no internal communications by modern standards, and there was discussion this morning, I think, which pointed out how the earth satellite can be used to improve communications within the borders of such nations.

All nations, in general, suffer from a deficiency of transoceanic communication, even the most modern and advanced nations. I would like to briefly point out what this situation is, talking in particular here with regard to transatlantic communications.

There is one transatlantic cable in operation today with a capacity of 36 voice channels. In 1950 there were approximately one and a half million messages transmitted across the Atlantic. Three million messages are expected in 1960. The capacity of the present cable, which is the one which was recently severed and which we all read about, will be exceeded by 1962 by voice communication alone.

By 1970 it has been estimated by the leading communications organizations in this country that we might expect 21 million transatlantic voice messages. How can we possibly meet this demand? There is another cable in the works which might be available about 8 years from now, but its capacity would be exceeded in 1965 and we haven't even begun to consider on this chart the requirements of



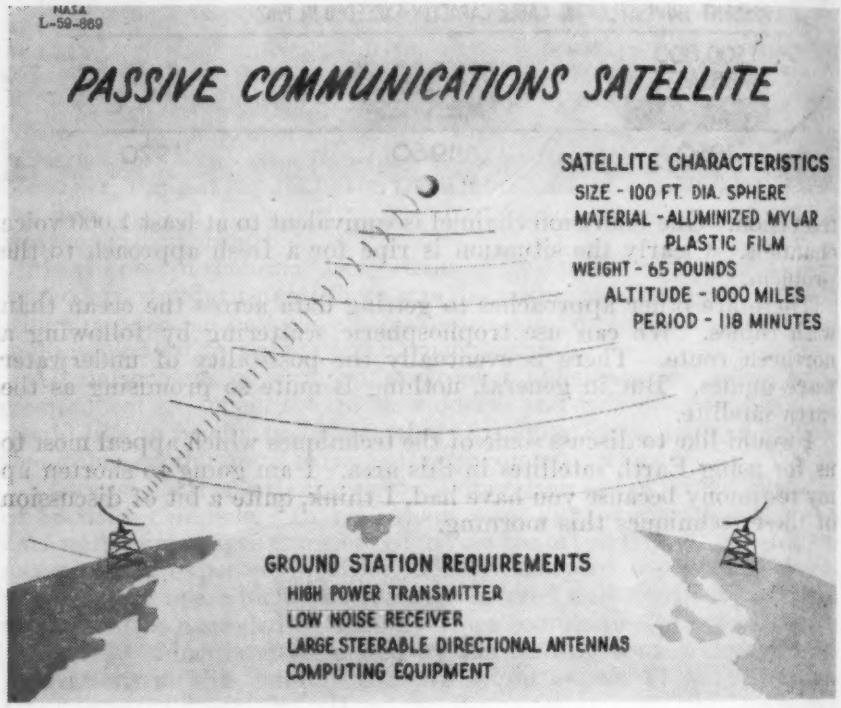
television. One television channel is equivalent to at least 1,000 voice channels. Clearly the situation is ripe for a fresh approach to the problem.

There are other approaches to getting data across the ocean than with cables. We can use trophospheric scattering by following a northern route. There is eventually the possibility of underwater wave guides. But in general, nothing is quite so promising as the earth satellite.

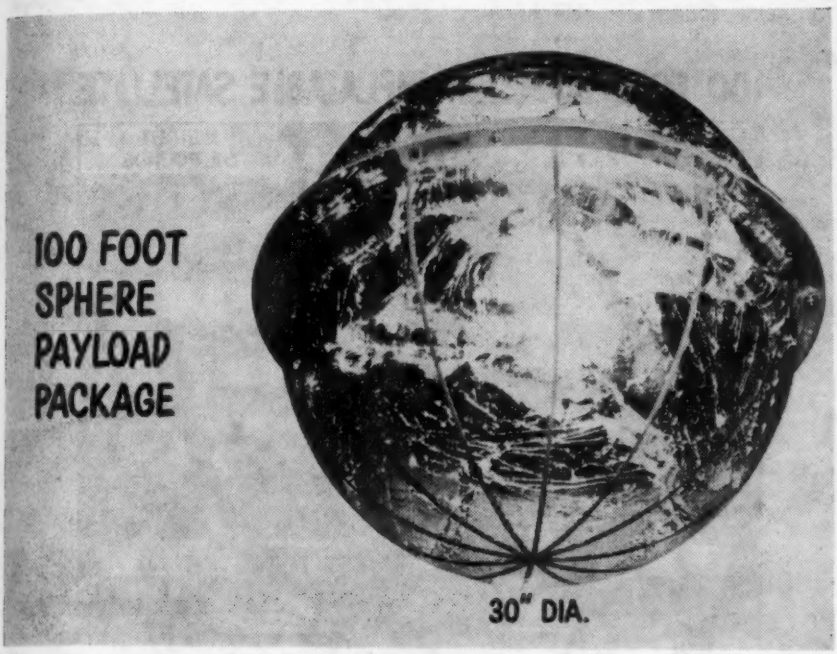
I would like to discuss some of the techniques which appeal most to us for using Earth satellites in this area. I am going to shorten up my testimony because you have had, I think, quite a bit of discussion of these techniques this morning.

The first approach you have heard about this morning, the passive communications satellite. The passive communications satellite as currently envisioned would be a large sphere which would probably be inflatable to minimize the weight. The technique of using this sphere is to beam a powerful high frequency signal at the sphere. This is done by carefully keeping track of the location of the sphere and feeding this information into the transmitting stations so that they know where it is and can direct their rather narrow beams toward the satellite.

When the beam hits the reflector it is reflected from it in an omnidirectional manner. A very weak signal reaches the earth over a very large area. Any antenna within this large area covered by the reflected wave can pick up this signal provided it is properly designed and the equipment is developed to go along with it. The equipment includes low-noise receivers and large and steerable transmitting and receiving antennas which are highly directional. In addition, there are associated computing equipment required to enable us to position these antennas.



This sphere about which we are talking, the first one, is 100 feet in diameter and is made of aluminized Mylar. At the end of my testimony I will have passed among you a sample of this material for your interest. The initial sphere has been designed to weigh 65 pounds and will be placed into a 1,000-mile orbit, approximately.



The next chart is a photograph of this sphere inflated at the Langley Research Center. The skin is only one-quarter of a mil thick, and yet it is quite strong. Recent developments have indicated that we may wish to double the thickness, and hence the weight would increase to about 150 pounds.

The aluminized Mylar reflects approximately 98 percent of the energy that impinges upon it.

The inflatable sphere is packaged in the nose of the launching vehicle in a case which would look something like this. This one happens to be made out of plastic so you can see the folded sphere within it.

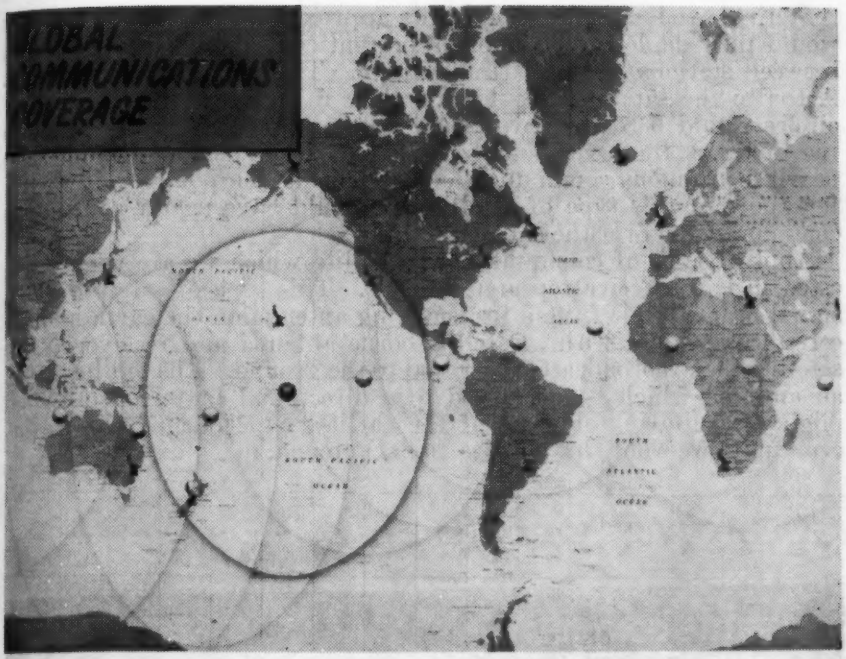
The technique is that at altitude, upon injection into orbit, the case separates and the sphere, which has been maintained at atmospheric pressure, is ejected.

Incidentally, am I holding this microphone too close? I don't need it.

The CHAIRMAN. Can everybody hear the speaker?

Mr. FULTON. Yes, much better.

Mr. CORTRIGHT. The trapped air within the sphere begins the initial inflation, and in addition, there is water placed in the sphere before launch. The water evaporates immediately upon the lowering of the pressure and continues the inflation until the sphere is fully inflated. This package is only 30 inches in diameter.



I would like to take just a moment with the next chart to show you how we might use a system of spheres. Dr. Pierce described this this morning but maybe with the aid of this chart it will be a little clearer to you.

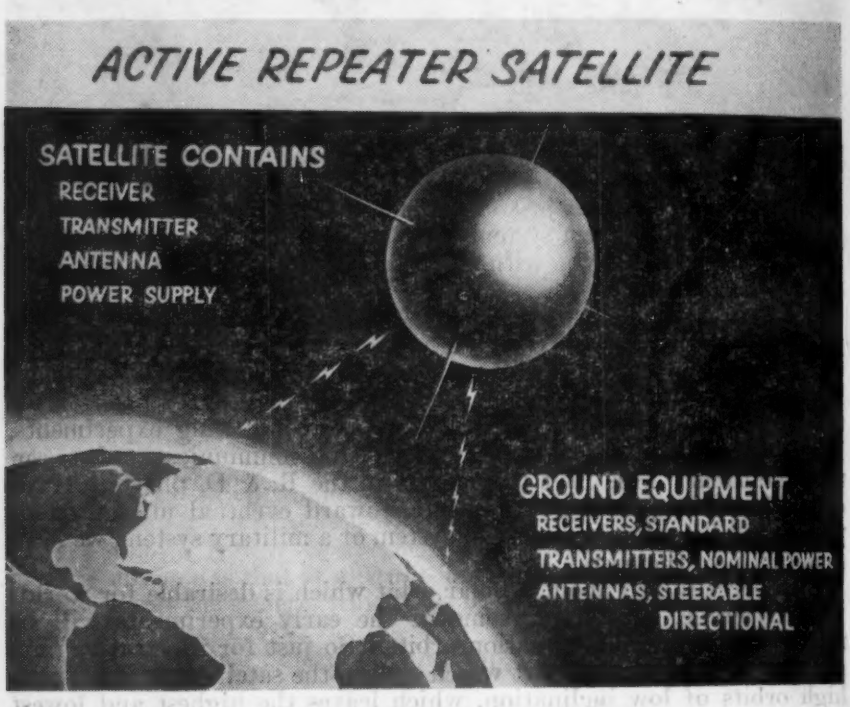
Our initial program will only put up one sphere at a time. We can use this satellite for reflecting signals for the research phases of the program whenever the satellite comes in to the proper position. During a certain portion of each day it will be in the desired position between the two stations with which we are conducting experiments. During the remainder of the day there is no communication between those stations. This isn't too serious in the R. & D. phases. However, if we are pointing, as we are, toward eventual utilization of passive satellites in a commercial system or a military system, we have to put more of them up.

Dr. Pierce talked about a polar orbit which is desirable for world-wide coverage. However, some of the early experiments will be made in these lower inclination orbits. So just for illustrative purposes, we have made a chart which shows the satellites in 2,500-mile high orbits of low inclination, which leaves the highest and lowest latitudes uncovered.

Each satellite may be utilized by any two stations which lie within the boundaries of the circle surrounding the satellite In other words, an antenna here could see an antenna here by means of reflection from the satellite. Once this satellite moves in position so that one antenna is no longer within this circle of coverage, it can no longer communicate with the other station unless another satellite has moved into position.

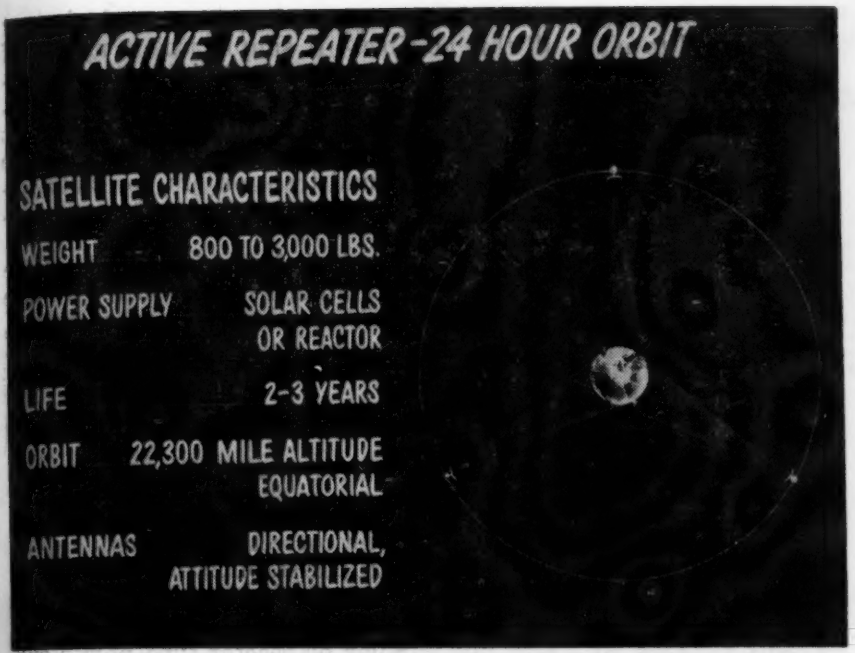
With these low inclination orbits approximately a dozen satellites would provide, let's say, 98 or 99 percent continuous communication between stations in this latitude range. This is an idealized chart. Actually the satellites wouldn't fall in a nice line like this. The circles would be displaced up and down. But I think the thing to remember is that within a band about this wide, we would have nearly continuous communication. By using the polar orbit with a few more of this type of satellite, we could have nearly continuous communication over the entire globe.

Another type of communication satellite which we are very interested in is the active repeater satellite. This type of satellite has a signal beamed to it from a transmitting antenna on the earth and receives that signal with a satellite-borne antenna and receiver. The satellite then rebroadcasts the signal to the ground. I have illustrated an antenna which is not suited to a directional pattern but which might be suitable for some of the earliest experiments. However, eventually we would have a directional antenna.



The requirements on the ground antennas are not quite so severe as with the reflector-type satellite because we have the opportunity to transmit a stronger signal to the ground. Ultimately, we would not use the omnidirectional antenna array here, and we would utilize a system much as shown on this final chart. You have seen this before today, but I will briefly repeat how we use this satellite system.

We are looking down on the earth from above a pole. These satellites are in a 22,300-mile orbit over the equator so that they move with the earth and remain overhead of an observer on the ground.


ACTIVE REPEATER-24 HOUR ORBIT
SATELLITE CHARACTERISTICS
WEIGHT 800 TO 3,000 LBS.
POWER SUPPLY SOLAR CELLS OR REACTOR
LIFE 2-3 YEARS
ORBIT 22,300 MILE ALTITUDE EQUATORIAL
ANTENNAS DIRECTIONAL, ATTITUDE STABILIZED

The technique of utilizing a system like this is to get a message from one side of the earth to the other would be as follows: The signal to get from this antenna to this one would have to go up to one satellite, be transmitted back down to an intermediate station, transmitted up again to a second satellite, and back down to the receiving station.

Of course within this portion of the world, say one-third of the world, only a single repeat would be necessary. But there are ranges which we would like to cover which would require this double repeat.

The weights of such satellites are beyond the capabilities of currently available booster systems, but booster systems are being developed which can put weights of 800 to 3,000 pounds in the 22,300-mile orbit. This is what we estimate will be required.

You will recall that this satellite ideally should be attitude stabilized so that its antenna may retain an orientation directed toward the earth's surface.

The power supply, it is estimated, can be solar cells. Under some conditions we might choose to use a reactor. This is an undecided matter at the present time.

The life of such satellites as currently envisioned would be in the neighborhood of 2 to 3 years.

Mr. FULTON. Before you leave that chart, why under the nature of physical things couldn't you have it repeated from satellite to satellite, rather than from satellite to ground station to satellite?

Mr. CORTRIGHT. This is possible, I think. But the requirements on the satellites get a little more severe under those conditions.

Mr. FULTON. There is no physical impossibility from doing that if you had enough power and enough room on the satellite?

Mr. CORTRIGHT. No, it is a natural thing to think of, and I don't think that anyone can say at this time that it won't be done that way. It might very well.

I would now like to summarize the types of equipment which must be developed to make all this possible. It simply isn't a matter of building the equipment and throwing up a commercial system tomorrow. There are items of equipment which are under research in various laboratories throughout the country, which are vitally important to the success of this system. They include for the passive satellite low-noise amplifiers, high power ground transmitters, low-noise directional antennas, fast tracking antenna mounts, and antenna pointing techniques.

For the active 24-hour satellite, they include the stabilized vehicle itself—after all, we have not yet flown an attitude stabilized vehicle other than by spin stabilization—orbit correction techniques—that is, station holding—antenna pointing systems from orbit, reliable satellite electronics, and power supplies.

SATELLITE COMMUNICATIONS DEVELOPMENT AREAS

PASSIVE SATELLITE	ACTIVE 24-HOUR SATELLITE
Low-noise amplifiers.	Vehicles.
High power ground transmitters.	Orbit correction systems.
Low-noise directional antennas.	Attitude stabilization systems.
Fast tracking antenna mounts.	Antenna pointing systems.
Antenna pointing systems.	Reliable satellite electronics.
	Solar or reactor-type power supplies.

Before concluding, I would like to just mention another requirement on communication satellites besides the commercial requirements of messages and television. The meteorological satellite, which is an additional satellite application of great interest, generates data in tremendous quantities, of the same order of magnitude as a television link. We feel that satellite data relays will be required.

These may or may not be borne in the meteorlogical satellites themselves. It may be that they require a special system.

This concludes the statement that I have prepared. We, of course, would be happy to attempt to answer questions. I recall that I left out a point I wanted to make on the passive satellite, and that is that it is very suitable for multiple usage. That is, different people can beam signals at it simultaneously, subject only to frequency allocation. Thus, any company that has the interest to proceed and cooperate with us in our first reflector satellite venture has an opportunity to study the technique of utilizing passive satellites for commercial enterprise.

The CHAIRMAN. Thank you very much, Mr. Cortright. We have a short statement from Mr. Newell D. Sanders, Assistant Director for Advanced Technology. Mr. Sanders.

Mr. SANDERS. I did not have a statement. Mr. Cortright covered it.

The CHAIRMAN. You are here to support Mr. Cortright in his statement. So is Mr. Leonard Jaffe.

Mr. SANDERS. The same is true of Mr. Jaffe.

The CHAIRMAN. Fine. We are happy to have all of you gentlemen here.

That being the case, that concludes the general statements. Now for questions. I have two or three little questions that I would like to ask. I would like to ask Dr. Pierce: How soon will we have commercial communications by satellite?

Dr. PIERCE. Mr. Chairman, I don't know.

The CHAIRMAN. That is a frank and forthright answer. Will we have Government operations with satellites? Will that be the rule, or will it be private business?

Dr. PIERCE. I don't know that. From the statement that has just been made by Mr. Cortright, it looks as if the Government will have satellites up before any private person will. How this will be organized, I don't know. It could be done under contract. It could be done in a cooperative way.

I just don't know and I am not really competent to deal with things like that.

The CHAIRMAN. We have some very optimistic statements, however, from Mr. Haviland on this. Perhaps he would want to hazard a guess on it. Would you do that, sir?

Mr. HAVILAND. As far as the capability of putting a satellite up for communications, the passive reflector system is essentially on the shelf right now. You have it in hand. It is a matter of allocating a booster to it. Isn't that correct?

Mr. CORTRIGHT. There is one scheduled to be launched this year.

Mr. FULTON. Mr. Haviland, you did make an estimate that we could have telegraphic communications satellites up, if you got the boosters provided for you, within a year. Is that not right?

Mr. HAVILAND. That is the next statement I was going to make. Assuming boosters were allocated, 1 year after the start of the program the first of the telegraphic systems could be put up.

The CHAIRMAN. Following that, you could complete the program, you said, within a year or two afterward?

Mr. HAVILAND. That's correct.

The CHAIRMAN. Would you envision that as being private enterprise or would that be Government operated?

Mr. HAVILAND. I believe that the proper way for these programs to develop is as a Government enterprise initially, with continued operation by commercial organizations and expansion moving toward the commercial field as rapidly as possible.

I believe this is the historical way many of our things have developed. It seems to have worked quite well.

The CHAIRMAN. Will the day come when the telephone service will include two-way television and we will have the capacity to use satellites for communications?

Mr. HAVILAND. I definitely expect this to happen, that we will have worldwide television operation, and a reasonable probability that this will be handled as the intercity television is now handled, by leasing or by renting services from one of the international communication organizations.

The CHAIRMAN. Instead of wires, you will use satellites?

Mr. HAVILAND. Satellite service, yes.

The CHAIRMAN. That will give you more channels, too.

Mr. HAVILAND. It could give you more channels. It could give you coverage in places you do not have now.

The CHAIRMAN. How many more channels would it give you?

Mr. HAVILAND. Looking at it from the standpoint of what is justified from the need for channels, it seems that somewhere in the range of 15 channels to any given area is in the upper limit of what is good enough.

In other words, more than 15 channels for Washington, D.C., is probably too many.

Worldwide, you would undoubtedly need 50, 100, or even 200 channels, to get sufficient worldwide coverage.

The CHAIRMAN. Dr. Busignies, I would like to ask you this: Do you see the major role of the I.T. & T. in communications satellites as building them for NASA or DOD or to serve the I.T. & T.'s own services?

Dr. BUSIGNIES. We have been active as a commercial enterprise in the communication field, and therefore we are quite interested in participating in the operation of a commercial system using satellites for long distance communication.

We realize, of course, not being in the business of sending missiles in the air, that we need to have the cooperation, or that we have to obtain the services of some Government organizations to facilitate the launching of the satellites in orbit. But, as far as the commercial aspect is concerned that a company like ITT would like to be able to operate commercially with a satellite in orbit.

The CHAIRMAN. You would have to depend on the Government, however, for boosters to get your satellite up. There is no alternative there, is there?

Dr. BUSIGNIES. Absolutely; yes.

The CHAIRMAN. There are no commercial interests that are building boosters to the point that you could say they could handle this by private enterprise, is there?

Dr. BUSIGNIES. Not entirely; no. We would absolutely have to rely on some Government services as far as the boosters are concerned.

The CHAIRMAN. At 22,300 miles up—and that is what you suggest—what effect would the Van Allen radiation belt have on satellite communications?

Dr. BUSIGNIES. That is a very interesting question. The first belt is close to the Equator, I mean within 1,000 miles or so. The second one is the one you are referring to, which is around ten to twelve thousand miles. It is understood from the recordings obtained from the Explorer, I think, that it decreases very quickly after that.

We are not absolutely sure of this, but we hope—and this will be confirmed in the near future—we hope that the radiation level at 22,000 miles is satisfactory. But it may require some precautions in the designing of the equipment.

The CHAIRMAN. What do you mean by satisfactory?

Dr. BUSIGNIES. Low enough not to damage the equipment for the period of years we are considering.

The CHAIRMAN. In other words, you hope that at the 22,300-mile level that the intensity of Van Allen radiation belt will be such that you can operate satisfactorily a communications satellite without serious interruption or reflection from that belt?

Dr. BUSIGNIES. Yes, but we are watching the result of every experiment being made right now. Each time a moon shot is made, of

course, a recording of the transmission is made. The first information came recently in December on the last moon shot.

The CHAIRMAN. I would like to ask Dr. Pierce: What effect does the elevation in temperature or the reduction in temperature at these higher space levels have on communications?

Dr. PIERCE. That is largely a matter of structure and the operation of electronic equipment.

A plastic balloon such as Dr. Cortright has described, if it unfortunately assumed a too high temperature would melt. So one has to make measurements and to try to estimate what the temperature might be. I gather that they believe it would be satisfactory.

We made some estimates that seemed to be fairly satisfactory.

The CHAIRMAN. As far as the actual transmission from the satellite to the earth, that is not as impeded by the elevation or reduction in temperature?

Dr. PIERCE. No; it isn't. It is just the operation of the apparatus or the survival of the satellite itself.

The CHAIRMAN. Mr. Fulton?

Mr. FULTON. May I question Dr. Haviland. I had a discussion with him on the question of telegraphic satellites. We will go back to that for a minute.

I believe that you have said that if you had a 500-pound payload in a satellite, Dr. Haviland, that you could have, within a year, a telegraphic satellite that carried 4 channels and 500 bits of information on each one of those channels, making 2,000 bits a second. Is that not right?

Mr. HAVILAND. That is correct.

Mr. FULTON. And that one of those channels might carry most of the messages, or one of those satellites might carry most of the messages for the United States?

But that if you had two of them, you could probably do it for the whole hemisphere. Is that not right?

Mr. HAVILAND. That is for present telegraph-type communication across the ocean.

Mr. FULTON. In complementing, really, or supplementing, we would be able to add on the present filled-to-capacity telegraph instruments with this method by two satellites?

Mr. HAVILAND. That's right.

Mr. FULTON. If the boosters were provided for you, which are in the process of development, and of which we have several possibly on hand, you would not be talking in the $2½ billion class that Dr. von Braun spoke about when he talked of such instrumentation, because he had the booster included. You would be talking in the neighborhood of possibly $100 million to $200 million in cost, would you not?

Mr. HAVILAND. That is correct. At the present time in the small satellites, the major cost is in the booster and in launching the booster. For the 500 pounds of payload, there is an appreciable development cost, but once you have determined how to build it, the cost of reproducing the equipment is quite low.

Mr. FULTON. Following up what has been said here by Dr. Cortright, the Chief of Advanced Technology of NASA, on the type of beams: The beams could be narrowed so that there would be no chance of somebody else picking up the information which is beamed because of the line of sight projection, could they not?

Mr. HAVILAND. This can be done. I should however like to note that as you make the beam narrower, you have an attitude control problem and antenna control problem that becomes much more severe. If you want to do it in 1 year, you probably have to take a wide beam. If you are willing to wait for 2 or 3 years, you can bring the beam width down because your ability to direct the antenna in the right place would go up.

Mr. FULTON. Using Dr. Cortright's reasoning again, by the operation of these repeater satellites we could store a repeater at various points on the earth so that as the satellite went around, it would then act as the repeater picking up from various stations with only a short time-lag on each repeater. Is that not right?

Mr. HAVILAND. You can do this, subject to—if you are going in one direction, in other words, if messages are going in the same direction that the satellite is going, it is pretty fast. But if they are going in the opposite direction it takes quite a while before the satellite goes the rest of the way around the earth.

Mr. FULTON. If the satellite were going around the earth 16 times a day it would be just an hour or so a day.

Mr. HAVILAND. That's right.

Mr. FULTON. Another thing is this: if anybody gets control through a space communications satellite so that they can drown out or jam all the airwaves of the world, we in this country would be in a pretty serious security position, would we not, as far as our radio communications are concerned, even communications that on the ground are dependent on radio? Is that not right?

Mr. HAVILAND. Subject to some limitations. There are a group of frequencies that will not penetrate through the ionosphere. If you are working below this critical frequency, no satellite could interfere with the ground communications.

Mr. FULTON. There are four stages of ionosphere. There is BC, DE, F–1 and F–2.

Mr. HAVILAND. Right.

Mr. FULTON. Which ones are you referring to?

Mr. HAVILAND. Each one of these has a cutoff frequency. The dominant one is usually the E layer in the daytime, and the F layer at night.

Mr. FULTON. So that would be under the 66,000-mile limit the ionosphere extends, and this would be at about what limit?

Mr. HAVILAND. Any frequency below 4 megacycles, which is considered high frequency, above the broadcast band—99 percent of the time would be free of satellite interference. Any frequency above that could be interfered with sometimes, depending on the exact ionosphere conditions.

When you get up to frequencies above 60 megacycles, a satellite properly located, with the proper amount of power, would be able to interfere, except for the case where you are using extremely directional antennas on the ground. The telephone company is using right now, and I think ITT also uses, towers about 30 miles apart, with directive antennas looking from one tower to the other. The satellite could not very well interfere with that.

Mr. FULTON. To put this interference from the satellite or jamming power into what we were talking about of the ionosphere, if we took

level D of the ionosphere and put that at 43½ miles, if we took the level of E and put that at 62 miles and level F–1 at 124 miles, and the F–2 at 186 miles, how much would be on each of those four layers that would be cut off by jamming from an outside satellite at 22,300 miles?

Would they be able to jam clear down through those four layers or not?

Mr. HAVILAND. At frequencies above 60 megacycles they would always be able to jam through all the layers. At frequencies below 4 megacycles they would never be able to jam through. Then the in-between range depends on the time of day and the condition of the sun, the sunspot cycle, and the location of the satellite.

It is very complicated to figure it out, but it can be determined.

Mr. FULTON. May I say to you what I think is the most important for our country, and I am going to recommend to this committee, that in order to advance this program of telegraphic satellites as well as NASA researches, that we set aside some of the deep space probes and moon probes we are talking about and go immediately into these telegraphic satellites and use the boosters for those.

Would you agree with that?

Mr. HAVILAND. The words "set aside" bother me.

Mr. FULTON. Postpone. Postpone those and use whatever boosters we have, as everybody admits we don't have enough to do every scientific experiment we want, and put them into the practical purpose of coming up within 1 year with a telegraphic satellite, or two.

Would you say that would be a wise course?

Mr. HAVILAND. I think we should definitely get after, on a national scale, building a communication satellite system. If it were necessary——

Mr. FULTON. With the highest urgency?

Mr. HAVILAND. With urgency. If it were necessary to set aside boosters, I would feel sorry for the person who had to make the decision; but I think he would be making the right decision if he did that.

Mr. FULTON. Thank you. May I close by saying that I welcome Mr. Haley as a fellow attorney, and because he always has unusual ideas. Let me question him about one or two of his unusual ideas I have found out through him.

He has come up and has discussed sometimes a peculiar term called "metalaw." Under metalaw, the law of outer space, I believe you said the Golden Rule does not apply. You can't expect other things out there, or people, to treat you as you want to be treated. You may have to treat them as they want to be treated, or would like.

Would you please tell us in your concept how that metalaw is going to apply: First, if we run into creatures of multidimensions out there; second, less than three dimensions; and lastly, if you run into a place where you are traveling and you lose one dimension.

I believe you have commented on all those. Will you please do that?

Mr. HALEY. This is purely a philosophical speculation which was inspired by Dr. Harlow Shapley and a professor at the University of California whose name I forget. There was speculation upon whether there are other planets in the galactic system which would approximate conditions on Earth, and also the speculation that appears to center on the size of the creatures.

This gets to be a very difficult problem. The point about it is, the human being on Earth must have a certain range of tolerance within frequencies, within background noise, so to speak. In other words, a human being is not injured by, say, 98.2 degrees of temperature. A human being has certain parameters within which he operates.

Mr. FULTON. But to go deeper, you are really saying that we should not attempt in the world to project any of our legal systems or our religious systems, based on the Golden Rule, beyond the world atmosphere out into space. That is really what you are saying.

Mr. HALEY. You are exactly right, Congressman. That summarizes the conclusion of what I was saying. In other words, the human being has his parameters of life and experience and so on, and the parameters of some other creature would probably be entirely different.

We could not project our parameters to control our association with these other creatures.

Mr. FULTON. I believe you likewise have said on any planet that we might come to, or star, that if there are creatures there, we should first get permission to land because they may have a different system and if we didn't do that, there would be chaos.

Suppose the Russians first get to the Moon and have a party there. Would you say that we should ask the Russians for permission to land before we got on the Moon?

Mr. HALEY. Oh, no, indeed not, because Russians are also human beings, I expect, like we are.

Mr. FULTON. Yes; but you then would apply to space creatures a rule that gives them the benefit, but you won't let the ordinary Earth creatures out there to do the same thing.

Mr. HALEY. That is true; but there is also the reverse. I am applying to Earth creatures the protection which I hope they will have from what might be superior space creatures. In other words, if we take the attitude that we are superior beings, we are liable to run across beings superior to us.

Instead of us enslaving somebody, they will enslave us.

Mr. FULTON. Do you believe that it is necessary for us to get permission from space creatures to land on any meteor, planet, asteroid, or star?

Mr. HALEY. If communications are possible and if we have reason to think that they are there. I only wish that the good sailors who landed on the West Indies would have taken this precaution, because they brought back certain diseases to Europe which have caused hundreds of millions of deaths in the meantime.

So we want to be very careful of those things. They also brought tuberculosis to the Polynesian Islands.

Mr. FULTON. You were the first one who ever projected those diseases into space, I might add.

Mr. HALEY. I imagine they are there, though.

Mr. FULTON. Thank you. That is all. I yield to my colleague from New York.

The CHAIRMAN. I recognize Mr. Anfuso.

Mr. ANFUSO. Dr. Pierce, do you see a real commercial future for communications using satellites which will be cheaper than present land-based systems?

Dr. PIERCE. I am not gifted with second sight, and it is very easy to be wrong. There is a difference between what will happen and the many things which might technically happen.

Right now I am quite optimistic about the commercial possibilities of satellite communication, but I realize that this will be a changing field. It will change with time, and I cannot clearly foresee all the things that satellite communication will be used for. I don't have any personal doubt that satellite communication will be used just as we now use transatlantic radio and transatlantic cables, for a wide variety of purposes.

But all this will come about in its own due time. Before that time we will undoubtedly learn a lot of things that will be necessary to understand that future, which I don't know right now.

Mr. ANFUSO. How about you, sir? How do you feel about that?

Dr. BUSIGNIES. This morning I mentioned a study we had made of the possible cost of an undertaking on the basis of an active satellite in contrast with the passive one. We are impressed by the fact that 48 channels, duplex, can be obtained with half a watt of power transmitted from such a satellite, or of the order of 1,000 channels, 500 duplex channels, with about 5 watts of power.

Being so impressed by the tremendous progress made in the missile art, if you look at the past schedule of events, the way I would like to put it is that if the missile scientists and engineers find a way to place a satellite and control its position, for instance, as in the 24-hour system, that we do know now how to make the radio system which will give up to 500 channels; we have to work further on the life of the components involved for obtaining a long life for the space radio system—which problem hasn't been solved yet.

We think that satellite communication for commercial as well as for military applications will develop.

Mr. ANFUSO. There is no question about the military uses. There is no question about that, how useful they can be. Are you also saying that commercially they can also be profitable?

Dr. BUSIGNIES. Yes, because our calculations have placed the range of cost of these channel miles just in the same range of cost as the present submarine cable, the telephone type submarine cable with repeaters.

Mr. ANFUSO. Thank you. Dr. Pierce, you said something about these satellites being in the public domain and that they would only be good if they are kept under some sort of control, and that they could be jammed. You say they could be jammed. I assume they could be jammed by the Russians or any other people. Is that correct?

Dr. PIERCE. Mr. Congressman, I am not sure whether I have used all the correct terms, but what I meant was that these satellites are up there where, either from Russian territory or from some other place, as you point out, signals could be directed at them. That is part of the problem. The other problem is they are up there and anyone else could direct signals at them. Thus there are two problems here.

One is the deliberate jamming. That has two aspects. One is, if they just put up there more power than you do, very much more power than you do, then you have no protection; you have very little protection. The other is that if there are active components up there,

and if they put up enough power, they will render those active components temporarily, at least, inoperative, incapable of carrying your signals. The components will be overloaded, so to speak.

Mr. ANFUSO. When you used the words "public domain," did you have in mind that some of these very early satellites could not possibly return into space, and therefore they would belong to the universe?

Dr. PIERCE. In a sense I meant that you have lost control over them when you put them up there. I mean you can't go up and erect a barrier in front of them and keep people from shooting waves at them, and things like that. You put them up there for your own purposes, but other people can direct radio beams at them and receive radio emanations from them just as well.

Of course this has many aspects. One is secrecy—I mean if you don't want somebody to do things. That can be taken care of by *coding. But there are other aspects of this. There is the* aspect I mentioned of keeping control over your own people who are using *them. If they try to use them in an unwise way, they will* ruin their own communication.

Mr. ANFUSO. These so-called balloon satellites—I think we can call these other satellites balloon satellites—they will only be about a thousand miles away from the others. Is that correct?

Dr. PIERCE. Yes. They might be a thousand miles up or they might be as much as 3,000 miles up. If you put them much farther than that, the powers required get so exorbitant they don't reflect enough back.

Mr. ANFUSO. We already have the thrust to put any amount of these up in orbit, don't we?

Dr. PIERCE. So I gather.

Mr. ANFUSO. It is only a question of appropriating the money to *do this sort of work. Isn't that right?*

Dr. PIERCE. So I gather.

Mr. ANFUSO. Now, if we wanted to go full speed ahead, we could put up a lot of these balloons?

Dr. PIERCE. That is my understanding. Of course you are getting here information secondhand for me, which the people from NASA could supply you firsthand.

Mr. ANFUSO. Mr. Cortright, what do you say about that?

Mr. CORTRIGHT. The putting of that balloon into a 900- to a 1,000-mile orbit has been held up somewhat by booster availability.

Mr. ANFUSO. Not that we don't have it, but it has been appropriated to some other functions?

Mr. CORTRIGHT. There have been problems associated with booster capability in guidance and propulsion. However, some of the versions which are available to us now and which are scheduled for the latter part of this year are capable of doing this particular job quite well, that is correct.

Mr. ANFUSO. These balloon satellites could not be jammed, I think you said. I think somebody said that—they could not be jammed.

Mr. CORTRIGHT. As I understand the jamming problem—and maybe Dr. Pierce would correct me if I am wrong—if the signal that you are sending is simple, such as a teletype signal, and you have wide-band width, you can put energy into coding techniques which will make it very difficult to jam.

Mr. ANFUSO. Do you agree with that, Dr. Pierce?

Dr. PIERCE. Yes, Congressman. If you don't try to send too much information and if you keep sending it on different frequencies, the problem of anyone trying to jam it is almost hopeless.

Mr. ANFUSO. What real commercial value could we see from these balloon satellites?

Dr. PIERCE. That depends, of course, on what the thing would cost. I am in no position to say that very accurately. We have looked into it a little. You could have considerable communication value. Technically, as far as I can see—that is, provided the satellites are up and provided nothing happens to them and they do stay spherical and stay up there—you could provide channels of as much as television band width, and a television channel you can equate to about 1,000 telephone channels.

So you could provide lots of communication over pairs of points of the order of a couple of thousand miles or so apart, which would span many oceans, either land to land, or island to island.

This is what you could do technically, as far as I can see it. It seems very close, though it is always easier to see what the problems are after you have done it than it is before.

Commercially, I am just not the right person to try to compare this with cable or other things. Some statements have been made about the cost of cable. On the other hand, we must understand that science and technology are advancing on many fronts, and future cables will be made which will carry more telephone conversations for a given cost.

Mr. ANFUSO. Let me ask Dr. Busignies: What commercial uses can you see for these balloons?

Dr. BUSIGNIES. We looked at it also. We also had access to all the information published by my friend, Dr. Pierce, here. We are somewhat afraid—for commercial use—of the large cost of the powerful transmitters necessary to establish the connection. We are a little ambitious and want to cover more than a transatlantic connection—say between the United States and England—and we want to try to take full advantage of this satellite to cover a large number of communication needs.

This is why we directed our study toward the active one. But for the passive, I would say that if a number of passive, big spheres like these mentioned were placed in orbit and would therefore become available to send back radio signals to Earth, we would certainly participate ourselves in a program of testing the use of the spheres for communications.

If they are made available, we are not going to neglect this particular aspect.

Mr. ANFUSO. You see great potentialities is this, don't you?

Dr. BUSIGNIES. Yes; I do.

Mr. ANFUSO. Does private industry intend in some way to cooperate with the U.S. Government not only in getting these balloon satellites up, but also in the maintenance of them?

Dr. BUSIGNIES. Yes. I checked with the management of the company, expecting that there might be such a logical question. The answer is "Yes," we would be willing——

Mr. ANFUSO. You are willing to spend money?

Dr. BUSIGNIES. We are willing to cooperate and spend money in the way we can, compatible with our research budget.

Mr. ANFUSO. And at the same time you would be saving the public a lot of money, too, wouldn't you, in the long run.

Dr. BUSIGNIES. We hope that would be a useful invention.

Mr. ANFUSO. Let me ask you gentlemen this: If we decide to use satellites to relay TV programs, will this require any changes in the present frequencies used for TV present channels as they are now allocated?

Dr. PIERCE. Should I reply to that, Congressman?

Mr. ANFUSO. Yes.

Dr. PIERCE. I want to reply partly because I want to be sure I understand this question. There are two ways you can use satellites to relay TV programs. One is just to take TV programs across an ocean for retransmission. I gather that that isn't what you had in mind.

That of course would be merely taking things from one station to another and there would be no change in frequencies.

As far as broadcasting television from a satellite in the near future, other frequencies than are now used would be more appropriate. However, the people would probably have, unless you wanted very large powers on the satellite—of course, I am not speaking very distantly in the future—to have very sensitive receivers and large antennas on their homes. With all deference to my colleague, Mr. Haviland, who is more optimistic than I am, I don't think this is a good way to broadcast TV.

Mr. ANFUSO. In other words, we might have to have new channels which would not be interfering with present channels?

Dr. PIERCE. No; I think not.

Mr. ANFUSO. In other words, you are not going to put them out of business?

Dr. PIERCE. If I might, Congressman, I would like to speak to the point that was raised before. Maybe I didn't understand your question about the commercial possibilities. There are two things. One is my telling you in all good faith and your believing me that I can guarantee that we will be using by some particular year satellites rather than submarine cables. I certainly wouldn't want to commit myself on that.

On the other hand, the Bell Laboratories are spending money right now on these satellite problems, as I outlined earlier.

Mr. ANFUSO. I knew you were, and as a matter of fact, that is why all this information here this morning and this afternoon indicates that you people are way ahead of the Government in this field.

I would like to ask you gentlemen this same question here. On the Garroway show today he stated that a poll taken of the American people—I heard this this morning—shows that the majority of the American people are not ready to go full-speed ahead on the exploration of outer space, that the majority of the American people prefer spending more money for medical research and juvenile delinquency.

I ask that because we on this committee here, after almost 2 months of hearings, all recognize the tremendous importance in going full-speed ahead on this program, and, therefore, this poll indicates that the American people are not fully alerted.

I think not only private industry but the Government, should do more to alert the American people. Do you agree, sir?

Dr. PIERCE. Mr. Congressman, I am all for space. I have been interested in it for years. I think it is a great challenge, and there are great benefits in satellite communication. But I would partly agree with these sentiments attributed to the American people in that I would hate to see all the country's wealth and power go into the exploration of space and to have these other areas of national strength neglected.

Mr. ANFUSO. I am glad to hear you say that. Of course, we should not neglect these other areas. But at the same time do you think we can afford to be behind Russia?

Dr. PIERCE. Mr. Congressman, I think we can't afford to be trailing Russia by trying to do everything that they do. It seems to me one must be reasonable about these things. I am sure that we are very interested in certain aspects of space that I haven't heard of the Russians saying much about. It seems reasonable to me that our governmental agencies are, too.

I certainly think that this country should do everything that is reasonable and wise about space. But we can't afford to be bamboozled by the Russians into rushing whatever way they go.

The CHAIRMAN. Will the gentleman yield?

Mr. ANFUSO. Yes.

The CHAIRMAN. I would like to put it this way: There is no use to build up our country, our roads, cities, canals, and rivers, and develop them all and then let the Russians come over and take them and use them.

Mr. ANFUSO. We would not have the problem of juvenile delinquency, for example, if the Russians came down and dropped all these intercontinental missiles, would we?

Dr. PIERCE. No, Congressman.

Mr. ANFUSO. I mean we would have no children at all to contend with, so there would be no problem of juvenile delinquency.

Dr. PIERCE. And the intercontinental ballistic missile is not the subject of this discussion. It is a thing of great urgency, but it is so urgent that it is almost separate from the space program as such.

Mr. ANFUSO. I am glad to hear you say that. In that field, at least, you recognize the fact that we must go full speed ahead. In order to attain that, incidentally, we must get this booster that we are all talking about which will help you to put all the satellites up in the air. Isn't that so, for peaceful purposes?

Dr. PIERCE. I would be very happy to be able to put things up more easily and frequently.

The CHAIRMAN. Would the gentleman yield there?

Mr. ANFUSO. Yes.

The CHAIRMAN. In reference to the deep space probes being separate from the ballistic missile program, of course, the probes used for deep space use the data and all of the secrets that we learned from the ballistic missile program. Likewise, we use the same booster for the ballistic missile program that we use for the deep space probe, isn't that right? So in effect they are interchangeable in many respects.

Dr. PIERCE. Yes, Mr. Chairman. This is an example of the power of technology and science. One part reinforces another.

Mr. ANFUSO. To get to my friend, Mr. Haley, you are associated in various businesses which have to do with the exploration of outer space. Do you believe that private laboratories such as you see here this morning should share the technology which they develop?

For instance, it isn't a question of Macy's telling Gimble's the selling point of merchandise, but here where we are trying to develop peaceful uses of outer space, do you think, for example, A.T. & T. should exchange information with the International Telephone & Telegraph Co.?

Mr. HALEY. The law pretty well takes care of it up to a point. In other words, procurement regulations in the basic statutes under which the Defense Department works, and now even more so under which NASA works, pretty well makes all this information available interchangeably among the companies in the United States.

But beyond that we still have our patent structure and know-how. We still have private enterprise in the American system and so on, and we also have a very potent thing called the Department of Justice and the various statutes they enforce, including the Sherman Act, Clayton Act, and so on.

So beyond saying that we should enforce the law, Mr. Congressman, I don't have any viewpoints as to whether they should freely exchange their information.

Mr. ANFUSO. Mr. Haley, you have raised a very interesting point. In other words, you say that because of our patent structure and maybe the desire for profit, that certain companies would try to keep information to themselves, which would cause us to be at a disadvantage to Russia, when everybody is cooperating there toward one goal.

Mr. HALEY. That is absolutely correct. That is part of what we pay for our own civilization.

Mr. ANFUSO. Do you believe, Mr. Haley, that there should be international cooperation at least among scientists in the free world in the exploration of outer space for peaceful purposes?

Mr. HALEY. I think that is essential. Certainly we had a very wonderful example of it in the International Geophysical Year, and also among the many scientific organizations, International Council of Scientific Unions, in the engineering organizations, the medical organizations, and so forth. They have all cooperated very well and have exchanged information to a reasonable degree.

It is at least far better than anything else we experience in civilization.

Mr. ANFUSO. One last question. Mr. Haley, I personally know that you have lectured—and I don't think I am saying anything confidential; if I am you can stop me—I know that you have lectured all over the world and that you have lectured behind the Iron Curtain. Is that correct, sir?

Mr. HALEY. I lectured at the University of Belgrade, Warsaw, Prague, Moscow, Leningrad, and others. I have talked there.

Mr. ANFUSO. You are, without stating your religion, you are a very religious person, aren't you?

Mr. HALEY. I don't know that I am a very religious person, but I am a religious person.

Mr. ANFUSO. During the course of your lectures I am told that you have taken scientists—for instance you took some scientists in Czechoslovakia, which is strictly an Iron Curtain country, you took these

scientists after you got through your lectures and you took them to church the next morning. Is that correct, sir?

Mr. HALEY. Yes, any place I go, Warsaw, I even took part of the American delegation to church in Moscow.

Mr. ANFUSO. And you did that for a definite purpose, didn't you?

Mr. HALEY. Yes. I wanted to let them know that we can be scientists and still believe in God. That is quite a point, I think.

Mr. ANFUSO. Mr. Fulton asked you some questions about what we would do in the event that other people—should there be people on other planets—would not allow us to go there. First of all, as to the Moon, I think it has been scientifically established that there is no life on the Moon, is that correct, sir?

Mr. HALEY. That is what Dr. Shapley tells me.

Mr. ANFUSO. Before I ask you that question, let us assume that there is some form of life on Venus. Let us assume that that form of life is far more advanced than ours, and they intend to invade the Earth. We would have every right to object, wouldn't we?

Mr. HALEY. We certainly would.

Mr. ANFUSO. In other words, what you said, you said in reverse. If there are people on Venus or any other planet, the humanitarian thing to do is ask permission of those people living there for permission to land a space vehicle or anything else. Is that what you had in mind, sir?

Mr. HALEY. Yes, I did. That is for two purposes, Congressman. One, to protect them—the other, to protect ourselves. We must have some knowledge of what we are heading into.

The same reason that we shouldn't have brought back those syphilis germs from the West Indies.

Mr. FULTON. How about Admiral Perry in Japan?

Mr. HALEY. Two wrongs don't make a right.

Mr. ANFUSO. Let him finish, Mr. Fulton.

Mr. HALEY. That is about all. It is both ways. There is one point I would like to make. I think Dr. Pierce overlooked something. That is, the use of these passive or active reflectors.

I think in the transmission of television programs, if we were going to use it, for example, as a vehicle to project our civilization, the only method we have, for example, we get a television program from Washington or New York to, say, Prague or to Moscow. It is not so costly, it would be by the very use of these satellites. I don't think he said that in his answer.

There is another very important use for these satellites, namely, in the field of television itself, you see, to transmit programs on the frequencies that are transmissionable. They would be picked up and then converted into the local frequencies used for dissemination to the general public.

The CHAIRMAN. Mr. McDonough?

Mr. MCDONOUGH. In connection with this communications system we are speaking about—that is, to have a satellite in a fixed position traveling at the same rate as the revolutions of the Earth—suppose we were able to land on the Moon the equipment that is equal to the satellite and use that as a stationary point for the transmission of communications.

Is that a practical thought? I mean, as practical as the satellite itself?

Dr. PIERCE. Certainly if one could ever land equipment on the Moon and have a power supply and have it maintained, one could have all sorts of communication with the earth. At present I think most people would agree that landing things on the Moon and setting them up is much more difficult than putting them in orbit.

There is another thing you might overlook, too, as far as telephone conversation goes. It would take over 2 seconds for something to get to the Moon and back, so you would have to wait for about 5 seconds for a reply, and thus you would have a very bad telephone circuit. The telephone circuit is just marginally satisfactory for a 22,000-mile satellite. If you go further than that, you get into delays that would make conversation very irritating.

Mr. MCDONOUGH. That is all.

The CHAIRMAN. You would have to drawl your speech out, wouldn't you? And then you would have to pause and count 10 before you got the reply.

Dr. PIERCE. That is right, sir.

The CHAIRMAN. Is that substantially it?

Dr. PIERCE. That is right, Mr. Chairman.

The CHAIRMAN. So you would have to have a special Moon dialect, wouldn't you?

Dr. PIERCE. Also, Mr. Chairman, of course you don't see the Moon 24 hours a day, so you would have communication only half of the day at various times of the day.

The CHAIRMAN. You mean when it is showing?

Dr. PIERCE. Yes.

The CHAIRMAN. Mr. King.

Mr. KING. Mr. Haley, you have called our attention to some legal problems that are arising out of our satellite activity, the control of these satellites and the matter of ownership ,and so on.

Do you feel that these legal problems should be settled by international treaty—the United Nations perhaps? And following it a step further, do you feel that Congress at this time should pass any legislation dealing with these particular problems?

Mr. HALEY. Congressman King, I feel very deeply and definitely that this committee should investigate these matters until it is satisfied that it has sufficient knowledge to make some recommendations or to write some legislation and so on.

Then of course it has to go to the State Department, and thence to the international organizations.

This committee also is bound, I think, within this term of Congress—or within this session of Congress and the next session—to write certain legislation in certain areas, particularly in the areas of communications.

So, therefore, legislation is one of the primary duties in this field of this committee—preparing legislation. This committee also will have to, under its terms of reference, look at the international picture. All implications of the international problems.

You are charged by your fellow Congressmen to do this. You have to do this. You have to go through the whole ambit of international problems and thoroughly investigate them. This means that you are going to have to spend a lot of time on it, I think. But there are very many definite problems involved. They are with us right now—not the problems of tomorrow. They are not great problems

such as who owns what, how far up is the air, and so on. That is a problem, but it doesn't necessarily begin there. It can begin at practical levels.

We can call the bluff of our enemies or people who are not peaceful with us many different ways if we just watch these factors. I think it is very important. You have to do it because this is the duty of the committee.

Mr. KING. Let me ask one other question. In your treatise, a portion of which I have read, you go into some detail on the line of demarcation between air and no air, suggesting that that particular line represents the legal boundary as well as the air boundary.

You have some fancy tests there and fancy language to determine where air stops. There is not agreement on that point.

But my question is: Couldn't that line be settled arbitrarily by treaty in terms of so many miles up, regardless of whether the air has actually ceased to exist at that level or not?

Mr. HALEY. Absolutely. All I am trying to do is to point out realistically what good scientists say on the subject. There is no great disagreement among the scientists as to what they believe on this subject. The atmosphere is something that is very, very definite. It is a viable gas, and it is a viable gas consisting of 80 percent nitrogen and 20 percent oxygen and some small portions of carbin dioxide and argon.

But these are diatomic molecules, you see. The point about it is that is what it is. When you get beyond the so-called atmosphere, these things dissociate. It is no longer atmosphere. It is no longer atmosphere—the sphere that gives you life, which is the meaning of the word, you see. It is something else.

You might say there is atmosphere between here and Outer Devron, if you want to say that a particle of some gas such as hydrogen is atmosphere. But that is not what air means.

Dog is dog; it is not dog is wolf. Dog is dog. Air is air. It is not something else.

On the other hand, there is no reason in the world why you couldn't make the jurisdictional line a thousand miles, 10,000 miles, anything you want. That is a matter for international agreement.

It is a matter of your own statutes. The trouble is our present statutes and the statutes of 88 nations—which the Library of Congress ran down for us, and is in one of your publications here that Dr. Sheldon gave you, which points out that there are 88 nations that have statutory law, municipal law, local law, which says they have sovereignty through the air, through the atmosphere, and it stops there.

So we are just in a no man's land now. If you want to make it a thousand miles up, that is up to this committee as far as I am concerned.

The CHAIRMAN. Mr. Quigley?

Mr. QUIGLEY. No questions.

The CHAIRMAN. Mr. Mitchell?

Mr. MITCHELL. No.

The CHAIRMAN. That seems to be it, gentlemen. I think that covers the subject. I gained, and I think the committee did, from what you gentlemen told us this afternoon, that one of the very practical

results of this inquiry into space is going to be the practical use of space for communications all over the world.

It is going to be economical and usable in a very short time. It may have a very profound effect on the future development of the whole world.

Am I putting it too strongly? Or too mildly?

Mr. HALEY. Too mildly.

The CHAIRMAN. Mr. Fulton wants to make a further comment.

Mr. FULTON. We on this side want to thank you gentlemen for coming. It was very instructive and helpful. It gives us a definite projection into the future.

Secondly, will you not, each of you, put at the highest point of priority—not only for economic development but for national security—the recommendation that we proceed immediately with the development of space and satellite communications systems and at a very rapid rate of acceleration.

May I have, each of you, answer on that?

Mr. HALEY. A very sound position.

Mr. HAVILAND. Very sound.

Dr. PIERCE. I would make only a reservation that we think over very carefully what we do; that we do it stage by stage and that we don't plan in detail for a future in which our state of knowledge will be radically different.

Dr. BUSIGNIES. Yes.

The CHAIRMAN. I want to thank all of you gentlemen for being here. I would like to add one more thing before we adjourn. I think that the background and the experience and the training and education of all of you should be in the record.

We have a statement here showing the record of Mr. Cortright, also Mr. Sanders who is here helping him, and Mr. Jaffe. But we have no complete statement showing the background and experience and training and ability and education of the others who have been nice enough to appear here today before this committee.

I think that ought to be in our record.

(The entries referred to have been added at appropriate places.)

The CHAIRMAN. If there are no further questions now, the committee will stand adjourned until tomorrow morning at 10 o'clock. We are going to take up another subject.

(Thereupon, at 3:42 p.m., the committee recessed, to reconvene Thursday morning, 10 a.m., in the caucus room of the Old House Office Building, March 5, 1959, on another subject.)

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